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AS - 508 S-IVB POSTFLIGHT LUNAR IMPACT TRAJECTORY ANALYSIS

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16. Abstract

This document presents analyses of the AS-508 S-IVB lunar impact. The lunar impact objective, a launch vehicle secondary objective, was to support the Apollo 12 passive seismic experiment by exciting the lunar structure upon impact and allowing the seismometer to record the event. In addition, an accurate postflight determination of the actual S-IVB impact time and location was desired. The results of the analysis of the lunar impact, tracking data, trajectory and resulting lunar impact conditions are given. Included is a description of the current best-estimate of the AS-508 lunar impact coordinates and a detailed trajectory listing from spacecraft separation to lunar impact

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SUMMARY

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INTRODUCTION

Lunar missions before Apollo 13 included the disposal of the spent S-IVB/IU stage as a desirable goal following spacecraft separation. This disposal was accomplished by lowering the energy of the translunar trajectory through retrograde thrusting, allowing the stage to pass by the trailing edge of the moon and "slingshot" into a heliocentric orbit. However, after the Apollo 12 Lunar Module (LM) ascent stage was intentionally impacted near the seismometer, producing seismic data which raised many significant and unanswerable questions about the nature of the moon's composition, an S-IVB/IU lunar impact was made a launch vehicle detailed objective for the Apollo 13 mission. Since the S-IVB/IU stage would have a terminal velocity and mass at impact several times greater than that of the LM ascent stage and would have a much smaller incidence angle, the prospect of using the spent stage to obtain seismic data was promising.

On April 11, 1970, the spent AS-508 S-IVB/IU stage was targeted to impact approximately 140 kilometers from the Apollo 12 seismometer. As a result of the impact, the seismometer signal was 20 to 30 times greater in amplitude and four times longer in duration than the Apollo 12 LM impact.

The real-time targeting of the S-IVB/IU was performed by a team of engineers at the Huntsville Operations Support Center (HOSC), Marshall Space Flight Center. Real-time tracking data were processed by both

the Manned Spacecraft Center (MSC) and Goddard Space Flight Center (GSFC) until the Command and Service Module/Lunar Module (CSM/LM) emergency occurred. Following the emergency, only GSFC continued providing real-time tracking state vectors, and all postflight tracking analysis was performed by GSFC. The results of this study are contained in Chapter II. Chapter I describes and evaluates the mission from the standpoint of objectives accomplished. Also included is an evaluation of the lunar targeting technique and a summary of the vehicle performance as significant from the standpoint of targeting and tracking analysis. Chapter III presents the best postflight estimate of the S-IVB/IU trajectory from spacecraft separation to lunar impact, along with related supplementary material. Chapters I and III were prepared by MSFC, and Chapter II was prepared by GSFC.

All event times given in Chapter I are measured in Ground Elapsed Time (GET) in units of HOURS:MINUTES:SECONDS. Ground Elapsed Time is measured from the point of vehicle range zero which is assumed to be 19:13:00 Greenwich Mean Time. All event times given in Chapters II and III are in Greenwich Mean Time (GMT) in units of DAYS/HOURS:MINUTES:SECONDS. In some cases, the measure of DAYS or SECONDS may be omitted.

CHAPTER I. MISSION ANALYSIS

By

W. D. McFadden

1.0 Introduction

To accommodate the S-IVB/IU lunar impact experiment, some vehicle hardware and software changes were made. On AS-507, following spacecraft separation, solar heat on the Instrument Unit (IU) caused the Command and Communications System (CCS) signal to drop out early in Timebase 8 (TB8). To enable the CCS to be used in lunar impact operations, a thermal shroud was placed over all IU components on AS-508. To allow tracking of the S-IVB/IU to lunar impact, a battery was added to the IU electrical system to provide power for operating the CCS transponder and power amplifier. The second S-IVB/IU cutoff Continuous Vent System (CVS) vent was shortened so that following Translunar Injection (TLI) an IU stage vector, stored at TB7 + 150.2 seconds and transmitted from the IU upon Hawaii acquisition, would show the entire propulsive impulse from the vent. And, the capability was added to the IU to accept a lunar impact Auxiliary Propulsion System (APS) burn command consisting of a pitch and yaw change in attitude, APS burn duration and start time.

1.1 Mission Objectives

Unlike previous vehicles, AS-508 included in its list of detailed objectives impacting a spent S-IVB/IU stage on the moon to obtain seismic data on the lunar structure (see reference 1). In detail, the lunar impact objectives were:

(1) Target the S-IVB/IU spent stage such that there exists a 50 percent probability of impacting within 350 km of the target site. The Apollo 13 lunar impact target site coordinates were selenographic longitude = 30°W and selenographic latitude = 3°S.

(2) Determine the actual impact time to within 1 second.

(3) Determine the actual impact point to within 5 kilometers.

A pre-mission study showed that these objectives were compatible from the standpoint of both the desired scientific objectives and technical and operational feasibility.

Because little was known about the maximum distance that an S-IVB/IU impact could be registered by the Apollo 12 seismometer, a target site approximately 200 kilometers from the experiment package was established. With the expected targeting accuracy, this provided a reasonable confidence that the impact would be recorded. If the distance of the impact from the seismometer and the times of impact and reception of the signal are known, then the speed of the seismic wave through the lunar material can be calculated. However, the certainty of this rate of travel is high only if sufficiently small dispersions are placed on the impact time and location determination. Dispersions of ±1 second in impact time and ±5 km in location were considered very desirable from the scientific standpoint.

Pre-mission analyses of real-time tracking vector accuracy indicated that these targeting objectives could be met. Postflight trajectory reconstruction experience indicated that the required tolerances on impact time and location are possible provided that tracking of the S-IVB/IU can be maintained until impact.

All of the objectives have been met with the exception of the final determination of impact location. Erroneous APS firings at approximately 19:29:10 GET imparted a tumble rate to the S-IVB/IU of several degrees per second which continued until impact. Since the unified S-Band transponder is located near the IU, the periodic movement away from and then toward the tracking station due to tumbling contributed a large short term variation of range rate tracking data at the ground stations. The data quality and resulting degradation of the trajectory determination are discussed in detail in Chapter II. However, a more accurate determination of the impact location is possible. If a photograph could be taken of the S-IVB/IU impact crater and surrounding landmarks from lunar orbit, a precise determination of its location would be possible. Such an attempt is planned on the Apollo 14 Mission.

1.2 Targeting Analysis

1.2.1 Lunar Targeting Program

All real-time S-IVB/IU lunar impact targeting was performed at MSFC with the UNIVAC 1108 Lunar Targeting Program (LUNTAR) with backup targeting performed in parallel on the CDC 3200 computer. The CDC 3200 version of LUNTAR uses the same targeting technique as the 1108 program.

This technique requires the use of the R-T-S targeting coordinate system defined in the appendix. Upon receiving an S-IVB/IU state vector in real time, initial guesses of the attitude and APS burn time are input to the program along with the desired target coordinates. The state vector is then integrated out to lunar encounter to obtain the nominal impact point for the initial guess maneuver. Then the initial guess for the lunar impact maneuver is perturbed independently in pitch, yaw, and velocity, and each of these perturbed trajectories are integrated to lunar impact to obtain linear partial derivatives in the R-T-S system. After solving a set of differential equations for a new pitch, yaw, and velocity change, the process is repeated until the maneuver is found which places the impact point within prescribed limits of the target. At this point, the same procedure is continued except that the partial derivatives are formed in the selenographic coordinate system, until the impact point lies within prescribed limits of the selenographic latitude and longitude of the target site. The LUNTAR Program output includes the required APS burn time and duration, pitch and yaw attitude changes and the octal command words for each of these parameters.

1.2.2 Real-Time Operations

After Earth Parking Orbit (EPO) insertion, state vectors based on Manned Space Flight Network (MSFN) tracking data were generated at MSFC and transmitted to the Lunar Impact Team (LIT) at MSFC. The EPO state vectors were then used to run 6-D simulated S-IVB/IU second-burn trajectories. These simulations were run by the Inflight Trajectory Team (IFTT). The output of these simulations was a post-TLI state vector which was then automatically fed into the LUNTAR Program. The LUNTAR Program modeled the predicted evasive burn, CVS vent, LOX dump, and APS lunar impact burn and determined the lunar impact point and required maneuver. For comparison, the impact points of all the real-time EPO vectors are numbered one through six in Table 1.1.

Following TLI, there were two state vectors which were compared with the EPO vectors. These are numbered seven and eight in Table 1.1. The "TB7 + 150" vector was an IU state vector which was stored in the IU at TB7+150.2 seconds and recovered upon tracking acquisition. The "BDAX 036" vector is the post-TLI solution based on the best available data.

In comparing the impact points of vectors 1 through 7 in Table 1.1, it appears that the impact point should be in the region of 40-43°W. However, when the "BDAX-036" vector was received, a shift appeared in the solution. As planned preflight, the best available post-TLI tracking vector, "BDAX-036," was used to compute the APS lunar impact burn. There

was also another consideration in the decision to use this vector. The "BDAC-036" vector impact point fell closer to the target than the previous vectors. This meant that should it be in error, a second lunar impact maneuver of minimal attitude change would be required. The possibility of a second lunar impact maneuver had been planned for preflight.

Following initiation of TB8, the actual velocity changes due to the evasive burn, CVS vent, and LOX dump were observed from telemetered accelerometer measurements. In addition, the S-IVB/IU total mass was calculated based on the actual evasive burn velocity change and the APS chamber pressures during the burn. The "BDAX-036" vector was then input to the LUNTAR Program with the actual velocity increments for the evasive burn, CVS vent, and LOX dump modeled. The resulting attitude change and APS burn duration were transmitted to MSC where the command was sent to the IU. Immediately after the command was sent, the vehicle executed the attitude maneuver, and at 6:00:00 GET, the APS burn to achieve the desired lunar impact occurred as planned.

At approximately 7:45:00 GET, MSC transmitted a second post-TLI tracking vector ("7:45" vector) which showed that the vehicle would impact at 30.9°W longitude and 8°S latitude. This impact point was used as a basis for determining the necessity of a second lunar impact burn.

The following criteria were used to make this decision:

(1) If the "7:45" tracking vector integrated to impact fell within 200 kilometers of the target site, then a second APS burn would not be needed.

(2) If the "7:45" tracking vector fell outside the 200 kilometer circle about the target site, the probability that the actual impact point would be within 350 kilometers of the target would be less than 50 percent. Therefore, a second APS lunar impact maneuver would be required and would occur at approximately 9:00GET to satisfy the lunar impact mission objective.

Based on a predicted impact point of 30.9°W longitude and 8°S latitude, the miss distance was approximately 150 kilometers. Therefore, no additional trajectory corrections were necessary. As later tracking vectors were received from MSC, the accuracy of the 6:00:00 GET maneuver was confirmed.

1.2.3 Targeting Accuracy

Because of the unplanned APS thrusting at 19:29:10 GET, the actual S-IVB/IU impact point does not necessarily reflect the accuracy of the real-time targeting. Figure 1.1 illustrates the change in impact point due to the anomalous APS thrusting. Also contained in this figure are the impact points of the "7:45" vector and the "TB7 + 150" and "BDAX-036" vectors with actual measured velocity changes modeled in the trajectory.

By comparing the projected impact point following lunar impact burn, based on postflight tracking analysis, with the target coordinates, it is seen that a miss distance of 115.6 km can be attributed to real-time targeting. The movement of the impact point due to the anomalous thrusting represents a distance of 149.5 km, moving the actual impact point 50.1 km closer to the target. Even if the anomalous APS maneuver had caused the trajectory to move in the opposite direction, the final impact point would still have been within 350 km of the target. However, if the lunar impact maneuver had been based on the "TB7 + 150" IU state vector, the impact point would have fallen outside the 350 km circle and would not have met the mission objective. Also of interest in Figure 1.1 is the relative accuracy of the "7:45" real-time tracking vector as compared to the GSFC lunar impact point solution before the anomalous thrusting.

1.3 Vehicle Performance During Translunar Coast

1.3.1 Performance Before Loss of Yaw Gyro

Relative to the lunar impact targeting, vehicle performance during Timebase 7 and 8 until loss of the primary yaw gyro at 12:47:00 GET was very close to nominal. The orbital energy at TLI reflected only a very slight underspeed condition relative to the TLI conditions given in reference 2. CSM/LM ejection was nominal and TB8 initiation was only four minutes late. Following initiation of TB8, the 80-second APS evasive burn, 300-second CVS vent and 48-second LOX dump were issued by the IU switch selector. Table 1.2 compares the actual and nominal ΔV's during TB8. The evasive burn, CVS vent, and LOX dump nominals are preflight computed based on nominal TLI conditions. The APS lunar impact burn nominal is based on the "BDAX-036" TLI conditions, and was computed as an output from real-time targeting. All TB8 ΔV's from the S-IVB/IU before anomalous thrusting were very close to nominal.

On AS-508, the total mass of the S-IVB/IU was calculated in real time from the following parameters.

(1) APS evasive burn thrust (lb) - calculated by observing APS ullage engine chamber pressures (100 psia in both engines) and reading the corresponding thrust (139.2 lb) from an AS-508 ullage engine thrust versus chamber pressure curve.

(2) Evasive burn duration (sec) - observed.

(3) Evasive burn ΔV (m/s) - observed from telemetered accelerometer readout.

Applying predicted mass losses due to venting and the LOX dump provides a vehicle mass history during TB8 (see table 1.3). Making the above calculation for the 6:00:00 GET APS burn gives an S-IVB/IU mass which is in close agreement with table 1.3. The lunar impact mass is the estimated dry mass of the S-IVB/IU.

Table 1.4 summarizes the actual and preflight nominal TB8 attitudes. The vehicle maneuvered to and maintained the actual attitude given in table 1.4 to within $\pm 1°$. The differences between the actual and the nominal APS lunar impact burn values are primarily due to differences between actual and preflight nominal TLI conditions and TB8 velocity increments through the LOX dump.

Figure 1.2 is a schematic of vehicle sun angles, the values of which are given in table 1.5 as a function of vehicle attitude. Table 1.5 also compares AS-508 and previous vehicle sun angles for the various attitudes.

1.3.2 Performance Following Loss of Yaw Gyro

At 12:47:30 GET, the yaw attitude error started to diverge due to loss of yaw rate gyro feedback in the control system, causing some erroneous APS yaw engine firing. When the backup yaw gyro took over, the yaw engine firing rate which had built up in magnitude and duration subsided to normal operation.

At 13:42:33 GET, the transposition, docking, and extraction (TD&E) attitude maneuver was performed for the second time due to inherent characteristics of the Launch Vehicle Digital Computer (LVDC) located in the IU. A counter in the LVDC overflowed at 13:24:07.4 GET after which it reverted to counting backwards. The TD&E maneuver was mechanized such that at the appropriate time in the reverse count it would be initiated a second time.

Loss of attitude control was experienced at 19:09:10 GET when the pitch and yaw attitude errors diverged to a maximum value of approximately 11.8 degrees, causing the APS control engines to fire to

establish pitch and yaw body rates of approximately -2 deg/sec. These rates were maintained to offset the constant attitude error signals.

At 19:29:10 GET insufficient electrical power caused a loss of yaw rate feedback in the control system. The loss of rate feedback, combined with the large attitude error signal, caused two yaw control engines to come full on. With loss of the yaw rate feedback, the control system could not correct for the rate imparted to the vehicle by the yaw engines and commanded the yaw engines to remain full on. Module 1 fuel depleted at 19:30:35 GET and Module 2 fuel depleted at 19:30:56.5 GET. Module 1 and Module 2 oxidizer depletion times were 19:31:16 and 19:31:34 GET, respectively. During the yaw engine firing, the pitch engines were fired in alternating series of pulses until propellant depletion.

During the yaw engine firing, a tumble rate, as well as a significant translational ΔV, was built up. In addition, because Module 2 yaw engine fired 21.5 seconds longer than Module 1, there was a significantly large roll rate imparted to the S-IVB/IU.

Evidence of the translational ΔV added to the stage can be seen in figure 1.3, which presents a plot of range rate data from two different tracking stations at the time of the erroneous yaw engine firings. The translational ΔV appears to be on the order of 2-3 m/s. The magnitude and effects of the resultant attitude motion due to this erroneous thrusting will be discussed in Chapter II. A more complete presentation of vehicle performance during IU lifetime is contained in reference 3.

TABLE 1.1 REAL-TIME STATE VECTOR LUNAR IMPACT POINTS

	1 IU INSERTION VECTOR	2 CANARY No. 1	3 CANARY No. 1*	4 CANARY No. 2*	5 CANARY No. 2†	6 CANARY No. 2††	7 TB7 150 IU	8 BDAX 036
SELENOGRAPHIC LATITUDE, DEG	-2.53	-6.33	-6.27	-9.18	-9.31	-9.18	-1.815	-4.03
SELENOGRAPHIC LONGITUDE, DEG	-34.57	-40.93	-42.11	-43.22	-40.77	-43.21	-41.96	-26.60
B·R. KM	-157	36	30	187	198	186	-210	-54
B·T. KM	671	318	253	203	338	204	263	1108

* FINAL PROPULSION DATA USED IN SECOND BURN SIMULATION

† PERFORMANCE ITERATION NUMBER ONE

†† PERFORMANCE ITERATION NUMBER TWO

TABLE 1.2 COMPARISON OF TB8 VELOCITY INCREMENTS

PARAMETERS	ACTUAL M/S	NOMINAL M/S	ACT-NOM M/S
APS EVASIVE BURN (80 SECOND DURATION)	2.98	2.90	0.08
CVS VENTING (300 SECOND DURATION)	0.44	0.50	-0.06
LOX DUMP (48 SECOND DURATION)	8.73	8.30	0.43
TOTAL	12.15	11.70	0.45

PARAMETERS	ACTUAL M/S	CALCULATED BASED ON ACTUAL VELOCITY INCREMENTS FROM APS EVAS. MAN. CVS & LOX DUMP	ACT-CALCULATED M/S
6 HOUR APS BURN (217 SECOND DURATION)	9.12	9.21	-0.09

TABLE 1.3 S-IVB/IU MASS HISTORY

EVENT	MASS
TIMEBASE 8, Kg (Lbm)	16647 (36700)
EVASIVE BURN TERMINATION, Kg (Lbm)	16624 (36650)
LOX DUMP INITIATION, Kg (Lbm)	16602 (36600)
LOX DUMP TERMINATION, Kg (Lbm)	15558 (34300)
APS BURN INITIATION, Kg (Lbm)	14833 (32700)
APS BURN TERMINATION, Kg (Lbm)	14787 (32600)
LUNAR IMPACT, Kg (Lbm)	13971 (30800)

TABLE 1.4 COMPARISON OF TB8 ATTITUDE TIMELINE

EVENT	ACTUAL		NOMINAL*		ACT–NOM	
	PITCH	YAW	PITCH	YAW	PITCH	YAW
APS EVASIVE BURN, DEG.	176	40	176	40	0	0
CVS VENT, DEG.	183	–5	183	–5	0	0
LOX DUMP, DEG.	183	–5	183	–5	0	0
APS LUNAR IMPACT BURN, DEG.	182	–8	183	–5	–1	–3
NOTE: ATTITUDES REFERENCED TO LOCAL HORIZONAL SYSTEM.						

*PREFLIGHT DETERMINED VALUES BASED ON OPERATIONAL TRAJECTORY IN REFERENCE 2.

TABLE 1.5 COMPARISON OF SUN ANGLES FOR VARIOUS VEHICLES

EVENT	AS-503		AS-505		AS-506		AS-507		AS-508	
	θ (deg)	ϕ (deg)	θ (deg)	ϕ (deg)	θ (deg)	ϕ (deg)	θ (deg)	ϕ (deg)	θ (deg)	ϕ (deg)
TD&E ATTITUDE	76	-47	64	10	69	9	77	-87	51	-66
EVASIVE MANEUVER ATTITUDE	*	*	*	*	*	*	17	-73	36	58
LOX DUMP ATTITUDE	76	-47	74	-10	104	-7	49	-75	24	-24
APS BURN ATTITUDE	76	-47	71	-10	100	-7	48	-80	10	-90

*THIS MANEUVER WAS PERFORMED BY THE CSM ON THE AS-503, 505 AND 506 MISSIONS, THEREFORE THE SIVB/IU WAS NOT REQUIRED TO MAKE THIS ATTITUDE MANEUVER.

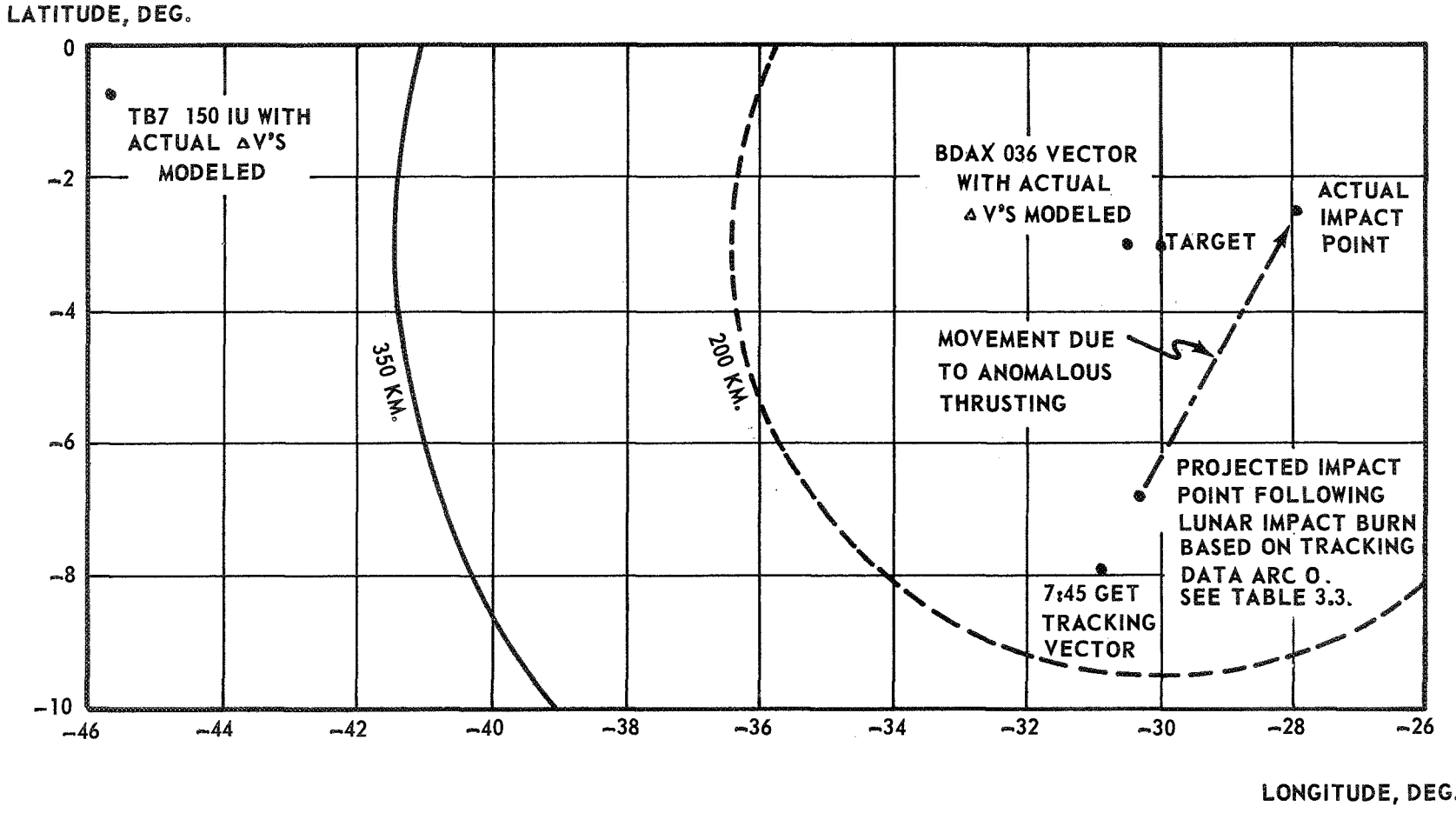


FIGURE 1.1 COMPARISON OF LUNAR IMPACT POINTS

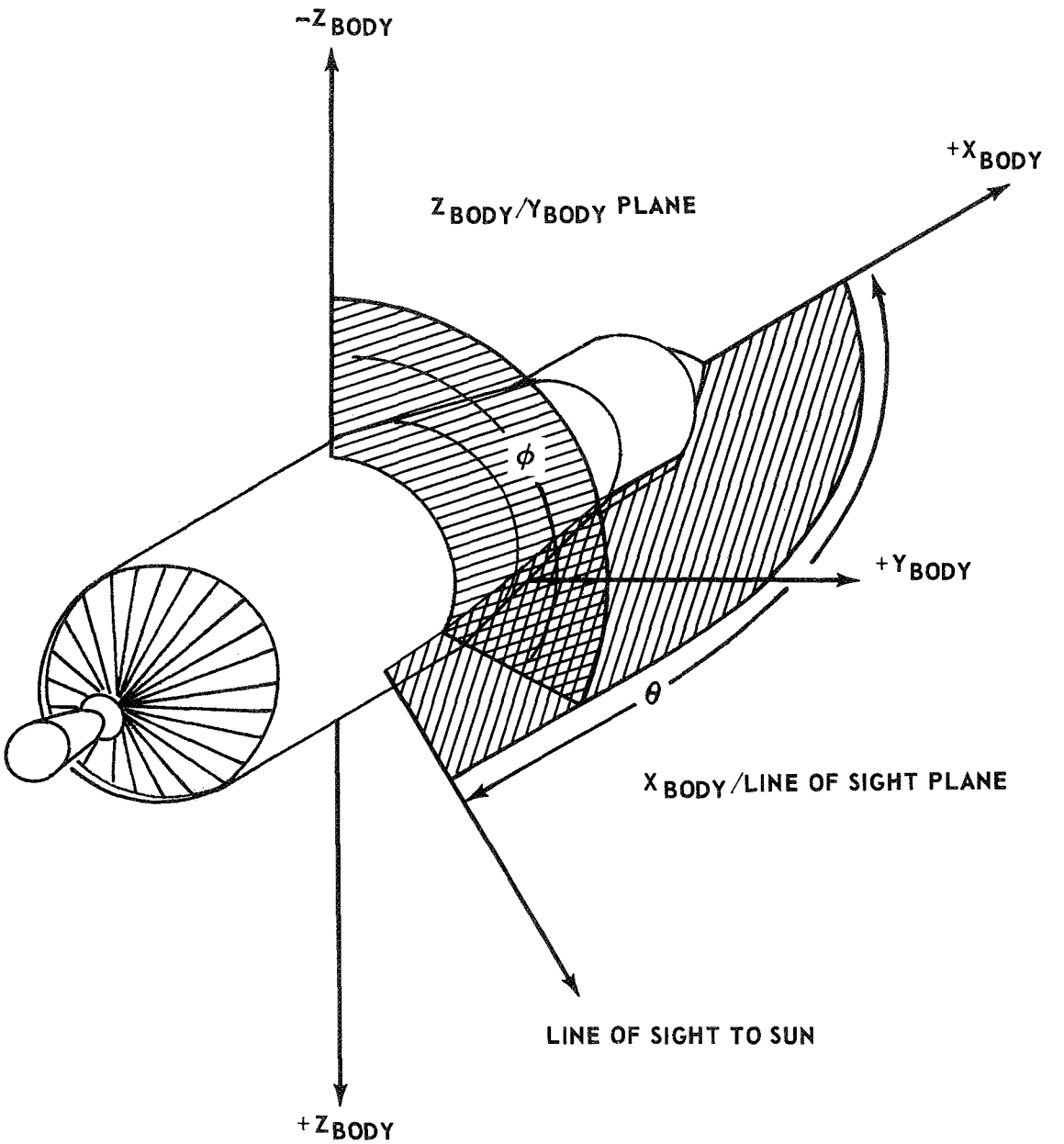


FIGURE 1.2 BODY-REFERENCED ORIENTATION ANGLES OF THE LINE OF SIGHT

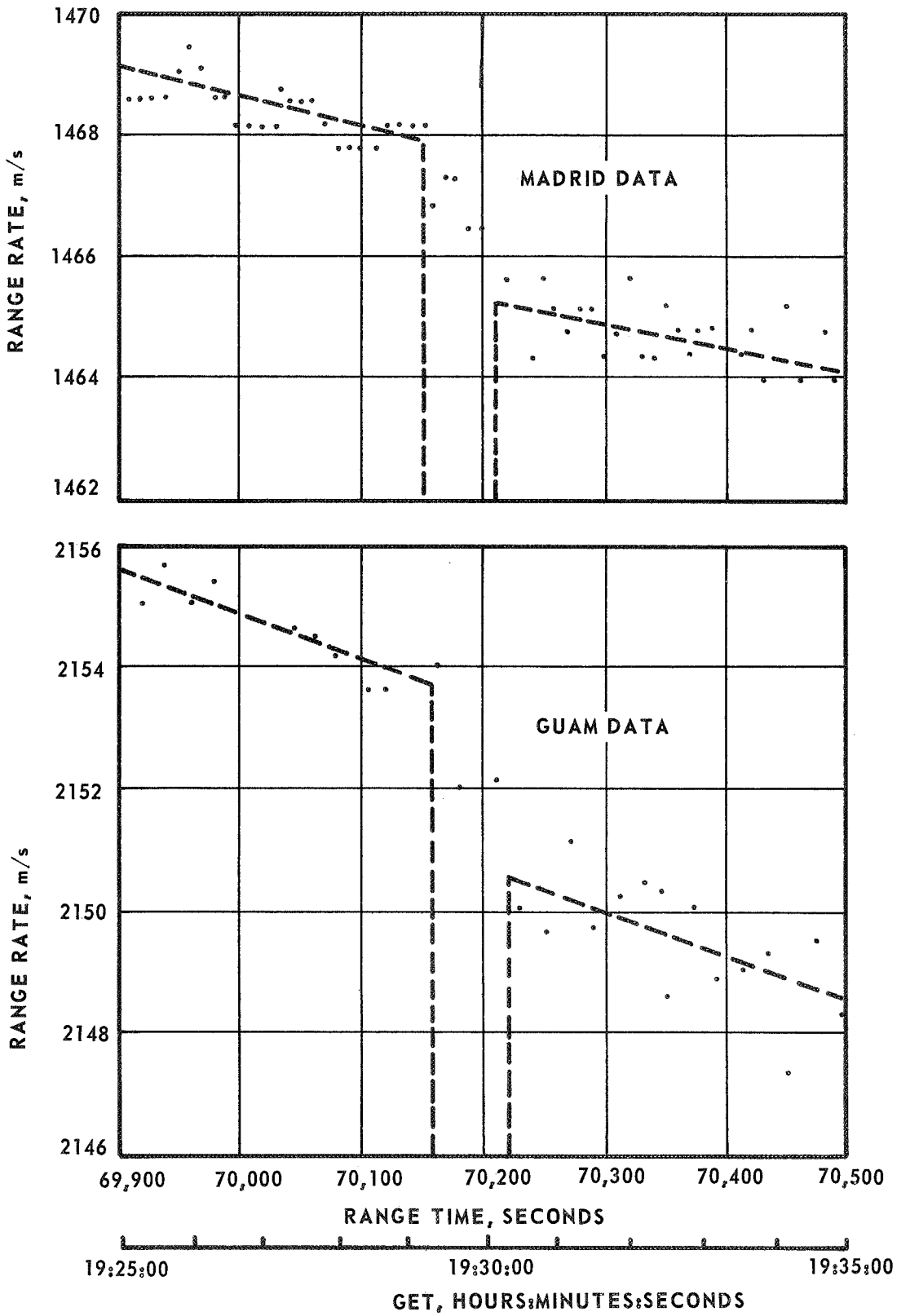


FIGURE 1.3 S-IVB/IU UNSCHEDULED VELOCITY CHANGE

CHAPTER II. TRACKING ANALYSIS

By

I. M. Salzberg

2.0 Introduction

In order to discriminate the tracking data characteristics for the AS-508 S-IVB/IU trajectory, it is necessary to establish the times of all propulsion events. Table 2.1 lists the significant trajectory events involving the S-IVB/IU from lift-off time to lunar impact.

This section analyzes all available Apollo 13 S-IVB/IU metric tracking data to (1) obtain the best estimated trajectory from TLI to lunar impact and thus obtain best estimates of the lunar impact point, (2) determine the accuracy of any such estimates, and (3) determine the existence of any tracker anomalies or subnominal tracker performance. To accomplish these objectives, the following paragraphs will discuss the analysis techniques used, data available, analysis results, and finally, conclusions.

2.1 Analysis Techniques Used

Apollo 13 S-IVB/IU trajectory and data analysis was accomplished at the Goddard Space Flight Center using two software systems. During the mission, the Goddard 360/75 Real-Time Computer System (GRTS) was used extensively to provide preliminary analyses. A more detailed investigation of mission data was conducted during and after the mission using the Data Evaluation Branch Tracking Analysis Program (DEBTAP) which is used with either the IBM 360/75 or 360/95 computer system.

A Bayes differential correction technique using least squares as a starter was used throughout the translunar mission phase by GRTS for orbit determination. Resulting vectors were propagated to a spherical-moon (1738.09 km) impact using an eighth order Adams-Moulton integrator. Just after impact, arcs consisting of the last 3, 11, and 16 hours of data were analyzed using the GRTS operating in the least-squares differential correction mode. The JPL lunar ephemeris designated DE-19 and lunar potential model designated L1 by MSC are used in GRTS. MSFN station locations shown in table 2.2 were used in all calculations.

DEBTAP uses a weighted least-squares differential correction technique to solve for the state vector, and is also capable of solving for up to 50 unmodeled error parameters. The integrator, earth geodetics, lunar ephemeris, and dynamic moon model used in DEBTAP are identical to those in the GRTS. DEBTAP and GRTS data processing has been carefully compared with both real and simulated near-earth, lunar, and transfer trajectory data. No significant discrepancies exist between the two systems when GRTS is used in the least-squares mode.

A third program called ORAN (ORbit ANalysis) was used to determine the effects of unmodeled errors and varying geometry on lunar impact predictions. This program develops simulated data for a specified trajectory, and with a priori knowledge of measurement noise and unmodeled or unadjusted systematic bias, computes the effect in modeled parameters. It is also capable of propagating measurement noise and unadjusted systematic bias to determine a realistic uncertainty associated with modeled parameters. In this particular analysis, frequency (or three-way range rate biases), range, and geodetic errors, along with range and range rate noise, were specified over segments of the actual Apollo 13 S-IVB/IU trajectory, and their resultant effect on the state (its uncertainty) at lunar impact was examined.

Every best-estimated S-IVB/IU trajectory was computed using all range (not just the first range) and range rate data available except where noted. Range and range rate were weighted at 15 meters and 3 millimeters per second, respectively. Because of the relatively large number of range rate observations and the weighting, correlated range data had little effect on best-estimated trajectory determination. The MSFN USB tracking systems provide an initial range, and subsequent ranges are developed from integrating doppler counts.

Post-TLI analysis was broken into two major parts. A best-estimated trajectory was computed with DEBTAP for the period from the end of the APS impact burn to the start of the S-IVB/IU anomalous thrusting (see table 2.1), and an error analysis was performed with ORAN to determine the accuracy of the predicted impact position. Earlier data contained many scheduled burns and venting, and the lengths of unperturbed trajectory arcs were too short to perform a meaningful analysis.

From the termination of the anomalous S-IVB/IU thrusting to lunar impact was the second major trajectory arc analyzed. This arc was divided into four segments (see table 2.3), and best-estimated trajectories and associated impact predictions were computed for each segment and combinations of segments. Several analyses were performed with ORAN to determine the uncertainty associated with these predictions. The purpose of performing the analysis in this fashion was to determine if data from various parts of the transfer trajectory were compatible.

It was hoped that unmodeled vehicle venting and data biases would be more clearly seen.

2.2 Data Available

Figure 2.1 is an events chart which not only shows planned and unplanned trajectory perturbing events but also graphically displays both two and three-way tracking site passes from TLI to lunar impact. Table 2.4 provides a list of the valid C and S-band tracking times, and indicates periods during which range data are available. Table 2.4 lists only those times when new and valid USB range acquisitions occurred. On April 12, at approximately 07:00 GMT, the MSFN USB sites switched from 1-per-6-second data rate to 1-per-10-second data rate. This latter data rate was maintained throughout the remainder of the mission.

Shortly after the explosion onboard the CSM/LM, communications with this vehicle (including tracking) were shifted to the LM frequency. It was decided that communications with the S-IVB/IU would be conducted at a frequency offset from the nominal to avoid interference with the CSM/LM. S-IVB/IU downlink frequencies used are also listed on table 2.4. On April 14, ETC (Engineering Test Center) and GDS acquired three-way signal lock at 19:26 GMT and 20:33 GMT, respectively, both using the same wrong downlink frequency for the extraction of doppler information. These sites were informed of their error, and both sites switched to the correct frequency at 21:56 GMT. By applying the proper frequency bias, it was possible to use these data in the analysis.

The ETC MSFN USB site located at GSFC was scheduled to track the S-IVB/IU in the three-way mode throughout the transfer trajectory by Goddard personnel to provide additional tracking geometry.

The time of S-IVB/IU impact can also be determined by noting when S-IVB/IU USB loss of signal occurred and subtracting the speed-of-light time delay from the observation. The result of this impact determination and computation for Apollo 13 is presented in table 2.5. The Madrid time is assumed to be in error by 1.0 seconds.

2.3 Analysis Results

2.3.1 APS Impact Burn to Anomalous Thrusting

A best-estimated trajectory (BET) using DEBTAP and 1-per-minute range and rate data was constructed from 102/01:16:37 to 102/14:42:10 GMT (days/hr:min:sec). In examining range rate residuals from this run

(figures 2.2 and 2.3), it was evident that propulsive thrusting was occurring from 01:16 to approximately 02:00 GMT and from 07:00 to 14:42 GMT. These data were subsequently removed from the arc, and a final BET was constructed using only the data from 02:00 to 07:00 GMT (arc 0). Figures 2.4, 2.5, 2.6, and 2.7 show graphically the resulting residuals, and table 2.6 summarizes the range and range rate residuals and range rate noise. Predicted impact point and time based upon the BET vector are shown in table 2.7.

Table 2.8 presents the results of various ORAN error analysis runs conducted for the complete arc. Additional error analysis computer runs for the shortened arc are not presently available. USB noise and biases used to perform the study are summarized in table 2.8.

2.3.2 Anomalous Thrusting to Impact

BET's were constructed for segments 1, 2, 3, 4, 12, 23, 34, 123, and 234. Mean station range rate and range residuals are tabulated in table 2.6, one-sigma range rate noise is compiled for each station for arcs 1 and 4 in table 2.6, and the predicted impact point and time, based on the various BET vectors, are contained in table 2.7. Table 2.9 summarizes the results of ORAN error analysis runs which match with DEBTAP analysis arcs.

GRTS lunar impact predictions based upon least-square BET's constructed during Apollo 13 for various combinations of arc length and data sampling intervals are presented in table 2.10. These values of selenographic latitude and longitude were the basis for GSFC's original estimate of the lunar impact point. This original estimate is graphically shown as an error rectangle in the center of figure 2.8. Similar DEBTAP BET's were determined after Apollo 13 in an attempt to verify these results. Table 2.11 compares DEBTAP and GRTS BET's that cover identical segments and have somewhat similar data. Identical data arcs are almost impossible to construct since different data collection schemes are used for DEBTAP and GRTS.

2.3.3 Impact Prediction Prior to Anomalous Thrusting

Before the anomalous thrusting between 102/02:00 and 102/07:00 GMT, computed lunar impact coordinates were as follows:

Selenographic Latitude = -6.81 degrees

Selenographic Longitude = -30.29 degrees

Impact time = 105/01:02:55 GMT.

An ORAN simulation that exactly parallels this analysis run is not available at this time. However, ORAN run number 05, summarized in table 2.8, approximates the geometry, and it is expected that actual results should be somewhat better since some HSKW data were used in the BET analysis arc. Thus, the one-sigma accuracy of the above prediction should, pessimistically, be .58 selenographic degrees.

2.3.4 Results of ORAN Simulations Between the APS Impact Burn and the Anomalistic Thrusting

Table 2.8 shows that a full 14-hour arc with no vehicle thrusting (ORAN run 01) reduces one-sigma impact uncertainties to 3.9 km when three geographically different earth tracking sites are used. Omitting the 2.5 hours of MADW two and three-way data (ORAN run 02) approximately doubles the uncertainty. If, in addition, three-way sites are omitted (ORAN run 09) the uncertainty again approximately doubles. A reduction in uncertainty from 1516 km to 59.1 km was realized using three-way data when only one two-way site was available.

A USB transponder antenna located on a tumbling or rotating vehicle produces a sinusoidal range rate modulating the transfer trajectory slant range rate. The tumble rate, the distance from the tumble axis, and the number of antennae affect both the amplitude and frequency of the modulation. If automatic antenna switching is used, a distorted or modified sine wave is encountered. Thus, spacecraft tumbling has the effect of increasing range rate noise and results in an almost linear increase in impact uncertainty due to noise only. USB one-sigma quantizing noise at a one-per-minute sampling rate was 5 mm/sec for Apollo 13, which is half of the observed noise tabulated in table 2.6. For Apollo 14 USB one-sigma quantizing noise will be reduced by a factor of 20 because of equipment improvements. Thus, the importance of minimizing the tumbling rate of the S-IVB/IU to obtain best possible impact predictions cannot be overemphasized.

2.3.5 Apollo 13, S-IVB/IU Best-Estimated Lunar Impact Position After the Anomalous Thrusting

A parametric graph of the data in table 2.7 for S-IVB/IU impact time and selenographic longitude is presented in figure 2.9. This figure shows the high correlation between these parameters which can be attributed to the rotational velocity of the moon about the earth. Based on these data and a known impact time from table 2.5, impact longitude appears to be between -27.9 and -28.1 degrees.

Figure 2.8 presents the results of tables 2.7 and 2.9. The fact that noise plus bias uncertainties as derived from ORAN do not overlap for all arcs indicates that one or a combination of the following may be occurring:

(1) Propulsive venting during arcs one and/or two.

(2) Tracker biases in excess of those estimated.

Since only one range acquisition was made by GDSW at 102/21:53 GMT, it is suspected that the 233 meter range bias observed was due to an incorrect ranging. The nature of the USB hardware is such that incorrect range acquisitions yield range errors in multiples of 300 meters. No other 14-hour arc produced range residuals of this magnitude. Repeated range acquisition by HSKW at 103/06:25, 07:11 and 07:14 GMT produced range residuals in arc 2 of less than 72 meters, and an average residual of -8 meters. However, when various 14-hour data arcs were combined, these same range data, in every case involving arcs one or two, yielded residuals in excess of 350 meters. It is suspected that no other abnormal tracker biases exist, but that some additional venting occurred somewhere in arcs 1 or 2. A careful examination of range and range rate residual plots for these arcs was unsuccessful in locating such an event. Data noise due to the spacecraft tumbling would, however, easily mask a small thrust sufficient to produce the observed results. It, therefore, appears wise to base an impact estimate upon data taken as close to impact as possible.

Figure 2.10 graphically displays the data from table 2.10 and 2.11 and also includes the results of arc 4. These results are responsible for the best lunar impact estimate. Small deviations (16 percent) in data used to construct BET's have a .1 to .4 degree effect upon estimate impact latitude as can be seen when comparing the results of arc 4 and arc 41. Data sampling interval variations have an even larger effect, and influence latitude estimates by .6 degree and longitude by .2 degree. Noise tabulated in table 2.10 and confirmed in table 2.11 is plotted in figure 2.11. For low data sampling intervals, RMS noise for range rate data climbs to almost 1 meter per second. Figure 2.12 graphically shows the near-sinusoidal variation of the range rate residuals from MAD at a 1-per-10-second sampling rate approximately 3 hours prior to impact. If range rate is rapidly varying due to a modulation, MSFN USB equipment will provide an average range rate over the sampling interval according to the following formula:

$$\dot{R}_{USB} = \frac{1}{\Delta t} \int_{t_o - .5\Delta t}^{t_o + .5\Delta t} \dot{R}_A(t)dt.$$

If $\dot{R}_A(t)$ is $-\dot{R}$ cos wt, it can be shown that the maximum $\dot{R}_{USB}$ that can be obtained is

$$\dot{R}_{USB/max} = \frac{2\dot{R}}{\Delta t\omega} \sin .5\omega\Delta t.$$

Since $\dot{R}_{USB/max}$ and ω for Δt = 10 seconds are available from figure 2.12, it is possible to solve for $\dot{R}$. That is,

$$\dot{R} = \frac{\Delta t\omega \dot{R}_{USB/max}}{2 \sin .5\omega\Delta t} = \frac{10 \frac{2\pi}{32.38} (1.2)}{2 \sin \frac{1}{2} \frac{2\pi 10}{32.38}} = 1.41.$$

Or the maximum actual range rate due to tumbling of the S-IVB/IU before impact is 1.41 meters per second. Since $\dot{R}$ is now known, it is possible to compute $\dot{R}_{USB/max}$ of .714, .116, .245, .108, and .079, respectively. To determine range rate RMS noise, it is necessary to apply the constant .707. Results are plotted on figure 2.11 and agree quite closely with observed range rate noise.

Since range rate noise is high for sampling intervals of less than 30 seconds, it would appear that use of these rates will lead to greater data sensitivity and a larger uncertainty in impact predictions. Figure 2.10 shows no significant indication of large uncertainty or dispersion with BET's using the higher data sampling rate. Further analysis is required to totally explain these results.

2.3.6 S-IVB/IU Tumble (Assuming Three USB Antennae)

Analysis of 1-per-10-second data indicates that the S-IVB/IU was tumbling approximately 3.7 degrees/second from the unscheduled thrusting to lunar impact.

2.4 Conclusions

1. Before the anomalous thrusting, best-estimate lunar impact selenographic coordinates are:

Latitude = -6.81 degrees

Longitude = -30.29 degrees

Impact time = 105/01:02:55 GMT.

2. Simulations indicate that, with 14 hours of MSFN USB tracking data, it is possible to predict impact position to within .5 selenographic degrees.

3. Apollo 13 S-IVB/IU best-estimated lunar impact position is:

Selenographic latitude = -2.5 ± .5 degrees

Selenographic longitude = -27.9 ± .1 degrees

Impact Time = 105/01:09:39.695 ± .015 second GMT.

It is felt that any further reduction in the uncertainties of these values will require an extensive additional analysis effort.

4. Tumble rate before impact is approximately 3.7 degrees/second.

TABLE 2.1 APOLLO 13 EVENT TIMES

Event	Day/GMT (Hr:Min:Sec)	GET (Hr:Min:Sec)
Lift-off	101/19:13:00 (April 11)	00:00:00
2nd S-IVB Cutoff	21:54:37	02:41:37
Translunar Injection	21:54:47	02:41:47
CSM Separation from LM/S-IVB	22:19:39	03:06:39
CSM Docking with LM/S-IVB	22:32:09	03:19:09
CSM/LM Ejection from S-IVB	23:14:01	04:01:01
Timebase 8 Initiated	23:30:59	04:17:59
Start of APS Evasive Burn	23:31:00	04:18:00
End of APS Evasive Burn	23:32:20	04:19:20
Continuous LH_2 Vent System (CVS) On	23:47:39	04:34:39
Start of LOX Dump	23:52:19	04:39:19
CVS Off	23:52:39	04:39:39
End LOX Dump	23:53:07	04:40:07
LH_2 and LOX Nonpropulsive Vent On (Latched Open)	23:54:19	04:41:19
Start APS Lunar Impact Burn	102/01:13:00	06:00:00
End APS Lunar Impact Burn	01:16:37	06:03:37
Start Anomalous Thrusting	14:42:10	19:29:10
End Anomalous Thrusting	~14:43:20	~19:30:20

TABLE 2.2 APOLLO 13 STATION LOCATIONS

Call Letters	Station	Site	Geodetic Coordinates			Geocentric Rectangular Coordinates				
			Latitude	Longitude	Height above ellipsoid (m)	Latitude	Radius (meters)	U (meters)	V (meters)	W (meters)
CKYF	Cape Kennedy	FPS-16	28°28'54.36"±1.0"	279°25'24.55"±1.2"	-14±40	28°19'14.77"	6 373 320	918 603±32	-5 534 755±38	3 023 550±34
MLAT	Merritt Island	TPQ-18	28°25'29.5"±1.0"	279°20'08.14"±1.2"	-16±40	28°15'50.66"	6 373 335	910 599±32	-5 539 121±38	3 018 004±34
MIL 3		USBS 30' MSFN(Dual)	28°30'29.78"±1.0	279°18'23.70"±1.2"	-18±40	28°20'49.84"	6 373 307	907 081±32	-5 535 231±38	3 026 129±34
PATQ	Patrick Air Force Base	FPQ-6	28°13'35.59"±1.0"	279°24'02.55"±1.2"	15±40	28°03'59.40"	6 373 429	918 602±32	-5 548 399±38	2 998 673±35
GBIT	Grand Bahama Island	TPQ-18	26°38'10.86"±1.0"	281°43'56.25"±1.2"	12±41	26°28'56.84"	6 373 909	1 160 070±32	-5 585 912±39	2 842 277±34
GBIF		FPS-16	26°36'56.80"(2)	281°39'07.80" (2)	14(2)	26°27'43.08"	6 373 917	1 152 464	-5 588 531	2 840 241
GBM 3		USBS 30' MSFN	26°37'58.29±1.0"	281°45'44.41" (2)	18(2)	26°28'44.32"	6 373 916	1 163 036 (2)	-5 585 478 (2)	2 841 934 (2)
GTKT	Grand Turk Island	TPQ-18	21°27'46.40"±1.0"	288°52'04.39"±1.2"	28±42	21°19'55.84"	6 375 352	1 920 453±33	-5 619 460±40	2 319 190±34
ANTQ	Antigua Island	FPQ-6	17°08'38.34"±1.1"	298°12'25.82"±1.2"	42±42	17°02'09.22"	6 376 364	2 881 615±35	-5 372 575±40	1 868 088±34
ANG 3		USBS 30' MSFN	17°01'00.71"±1.1"	298°14'49.86"±1.2"	34±42	16°54'34.14"	6 376 383	2 887 319±35	-5 374 194±40	1 854 638±34
BDAF	Bermuda	FPS-16	32°20'53.04"±1.2"	295°20'46.61"±1.4"	- 5±43	32°10'27.76"	6 372 075	2 308 902±39	-4 874 327±41	3 393 116±39
BDAQ		FPQ-6	32°20'52.54"±1.2"	295°20'46.82"±1.4"	- 4±43	32°10'27.26"	6 372 076	2 308 911±39	-4 874 333±41	3 393 103±39
BDA 3		USBS 30' MSFN	32°21'04.50"±1.2"	295°20'30.84"±1.4"	- 2±43	32°10'39.19"	6 372 077	2 308 450±34	-4 874 336 ±41	3 393 416±39
CYI 3	Grand Canary Island(G)	USBS 30' MSFN	27°45'52.33"±4.6"	344°21'59.79"±1.3"	173± 51	27°36'22.41"	6 373 728	5 439 152±40	-1 522 056±40	2 953 537±40
ASCT	Ascension Island (G)	TPQ-18	-07°58'21.00"±3.4"	345°35'56.50"±2.3"	103±73	-07°55'11.34"	6 377 860	6 118 539±43	-1 571 084±103	- 878 787±105
ASCF		FPS-16	-07°57'04.51" (2)	345°35'17.22"±2.3"	70 (2)	-07°53'55.34"	6 377 829	6 116 523(2)	-1 572 322(2)	- 876 455(2)
ACN 3		USBS 30' MSFN(Dual)	-07°57'17.26"±3.4"	345°40'23.32"±2.3"	522±73	-07°54'08.02"	6 378 280	6 121 231±43	-1 563 338±103	- 876 905±105
PRE 5	Pretoria, South Africa	MPS-25	-25°56'37.44±1.4"	28°21'30.56"±1.5"	1626±43	-25°47'33.74"	6 375 727	5 051 635±43	2 726 681±43	-2 774 184±43
CROQ	Carnarvon, Australia (G)	FPQ-6	-24°53'47.00"±2.3"	113°43'05.10"±1.0"	- 11±83	-24°44'59.17"	6 374 390	-2 328 496±70	5 299 917±70	-2 668 677±70
CRO 3		USBS 30 MSFN(Dual)	-24°54'23.68"±2.3"	113°43'34.51"±1.0"	- 15±83	-24°45'35.69"	6 374 383	-2 329 059±70	5 299 146±70	-2 669 699±70
WOMF	Woomera, Australia	FPS-16	-30°49'11.02"±2.3"	136°50'13.16"±2.5"	151±30	-30°39'02.50"	6 372 739	-3 998 928±70	3 750 388±70	-3 248 840±70
GWM 3	Guam (G)	USBS 30' MSFN(Dual)	13°18'38.07"(2)	144°44'12.47"±1.7"	143±55	13°13'28.64"	6 377 183	-5 068 938(2)	3 584 123(2)	1 458 903(2)
HAWF	Hawaii (G)	FPS-16	22°07'24.61"±2.3"	200°20'05.52"±1.2"	1125±43	21°59'22.57"	6 376 279	-5 543 940±70	-2 054 602±70	2 387 523±70
HAW 3		USBS 30' MSFN(Dual)	22°07'34.71"±2.3"	200°20'06.94"±1.2"	1135±43	21°59'32.62"	6 376 288	-5 543 825±70	-2 054 602±70	2 387 815±70
CALF	Pt. Arguello, Calif.	FPS-16	34°34'58.45"±1.0"	239°26'19.86"±1.2"	646±40	34°24'11.95"	6 371 963	-2 673 158±33	-4 527 065±36	3 600 263±34
GYM 3	Guaymas, Mexico	USBS 30'	27°57'47.54"±1.0"	249°16'44.94"±1.2"	- 22±41	27°48'14.90"	6 373 472	-1 994 682±33	-5 272 969±36	2 972 909±33
WHSF	White Sands, N. M.	FPS-16	32°21'29.60"±1.0"	253°37'49.57"±1.2"	1232±40	32°11'04.33"	6 373 310	-1 520 192±31	-5 175 317±37	3 394 730±33
TEX 3	Corpus Christi, Tex.	USBS 30' MSFN(Dual)	27°39'13.50"±1.0"	262°37'17.51"±1.1"	-20±40	27°29'45.09"	6 373 569	- 726 057±30	-5 606 822±38	2 942 578±32
EGLF	Eglin Air Force Base	FPS-16	30°25'18.36"±1.0"	273°12'06.79"±1.2"	28±40	30°15'14.45"	6 372 746	307 465±31	-5 496 185±38	3 210 810±33
MAD 8	Madrid, Spain (J)	USBS 85' MSFN	40°27'17.97"(2)	355°49'55.22"(2)	778(2)	40°15'54.48"	6 369 986	4 847 837(2)	- 353 280(2)	4 117 084(2)
MADW	(ROBLEDO) (J)	USBS 85' DSN(Dual)	40°25'41.85"(2)	355°45'05.29"(2)	770(2)	40°14'18.46"	6 369 987	4 849 248(2)	- 360 236(2)	4 114 823(2)
HSK 8	Canberra, Australia (J)	USBS 85' MSFN(Dual)	-35°35'00.58"±2.3"	148°58'41.83"±2.5"	1145±30	-35°24'05.85"	6 372 110	-4 451 095±70	2 676 784±70	-3 691 391±70
HSKW	Tidbinbilla, Australia (J)	USBS 85' DSN(Dual)	-35°24'03.56"±2.3"	148°58'54.34"±2.5"	670±30	-35°13'10.23"	6 371 699	-4 461 002±70	2 682 374±70	-3 674 626±70
GDS 8	Goldstone, Calif. (J) (Mojave)	USBS 85' MSFN(Dual)	35°20'29.74"±1.1"	243°07'36.48"±1.2"	907±40	35°09'36.91"	6 371 958	-2 354 722±34	-4 646 795±37	3 669 390±35
GDSW	(Pioneer)(J)	USBS 85' DSN(Dual)	35°23'22.45"±1.1"	243°09'03.70"±1.2"	971±40	35°12'29.25"	6 372 005	-2 351 389±34	-4 645 088±37	3 673 768±35
TANF	Tananarive	FPS-16	-19°00'10.87"(2)	47°18'52.74"(2)	1319 (2)	-18°53'05.60"	6 377 235	4 090 850(2)	4 435 487(2)	-2 064 106(2)
WLPQ	Wallops Island	FPQ-6	37°51'36.83"(2)	284°29'26.49"(2)	14(2)	37°40'26.17"	6 370 168	1 261 623(2)	-4 881 604(2)	3 893 236(2)
WLPF		FPS-16	37°50'28.72"(2)	284°30'53.63"(2)	11(2)	37°39'18.17"	6 370 172	1 264 007(2)	-4 882 316(2)	3 891 577(2)
CALT	Vandenberg AFB, Cal.	TPQ-18	34°39'57.62"(2)	239°25108.31"(2)	108(2)	34°29'10.35"	6 371 395	-2 671 837(2)	-4 521 246(2)	3 607 534 (2)

(2) Uncertainties not available "(Dual)" indicates a common antenna, two receivers and two transmitters. Geodetic coordinates referenced to the Fischer Ellipsoid of 1960. The Geocentric Rectangular Coordinate system consists of a u-axis at the intersection of the earth's equatorial plane with the Greenwich meridian, a w-axis along the earth's rotational axis, and a v-axis such to complete a right-handed coordinate system.

(J) JPL derived coordinates.

(G) GSFC derived coordinates.

GSFC
DEB
1-26-70

TABLE 2.3 APOLLO 13 S-IVB ANALYSIS TRAJECTORY ARCS

Arc	GMT (Day/Hr:Min:Sec)
0	102/01:16:37 - 102/14:42:10
1	102/14:43:20 - 103/04:22:00
2	103/04:23:00 - 103/20:00:00
3	103/20:01:00 - 104/10:30:00
4	104/10:31:00 - Impact

TABLE 2.4 APOLLO 13 C- AND S-BAND S-IVB DATA FROM TLI TO IMPACT

Site	Tracking Period (GMT) Range Rate	Range	Down Link Frequency*	Comments
C-Band				
MIL TPQ-18	N/A	101/22:11:48 - 102/06:21:06	N/A	
HAW	N/A	101/21:56:24 - 102/02:51:18		
BDA FPQ-6	N/A	101/22:16:00 - 102/05:33:54		
CRO	N/A	102/05:57:36 - 102/06:21:18		
CRO	N/A	102/07:23:42 - 102/07:52:24		
USB 2-Way				
GDSW	101/22:15 - 102/00:30	Not tabulated	1	
MIL	102/00:31 - 102/00:39	Not tabulated	1	
GDSW	102/00:40 - 102/06:13	Not tabulated	1	
HSKW	102/06:14 - 102/12:00	Not tabulated	1	
MADW	102/12:01 - 102/21:13	15:02, 17:52, 18:03, 12:30 19:02, 20:01, 14:37, 14:44	1	
GDSW	102/21:14 - 103/04:22	21:53	1	Data not analyzed from 03:07 to 04:01 (single acq; large bias, approx 233 m)
HSKW	103/04:23 - 103/13:13	06:25, 07:11, 07:16	1	

TABLE 2.4 (Continued)

Apollo 13 C- and S-Band S-IVB Data from TLI to Impact - Cont.

Site	Tracking Period (GMT)		Down Link Frequency*	Comments
	Range Rate	Range		
MADW	103/13:14 - 103/19:59	None	1	
GDS	103/21:14 - 103/22:09	None	1	
MADW	103/22:10 - 104/02:03	None	1	
GDSW	104/02:04 - 104/04:53	02:16, 02:30, 02:40, 02:50, 02:55, 03:08, 03:12, 03:17, 03:32, 03:43, 04:01, 04:24, 04:31, 04:50	1	
HSK	104/04:54 - 104/13:16	None	1-2	Frequency shift occurred at approximately 104/09:00. No 2-way site from 104/07:00 to 104/09:00.
MAD	104/13:17 - Impact	None	2	
USB 3-Way		N/A		
ETC	101/22:11 - 102/06:12		1	
TEX	101/22:21 - 102/06:21		1	
HAW	101/22:13 - 102/06:21		1	
MIL	101/22:11 - 102/06:21		1	
GDSW	102/00:21 - 102/00:39		1	
GWM	102/02:33 - 102/06:21		1	

TABLE 2.4 (Continued)

Apollo 13 C- and S-Band S-IVB Data from TLI to Impact - Cont.

Site	Tracking Period (GMT)		Down Link Frequency*	Comments
	Range Rate	Range		
HAW	102/08:45 - 102/11:58		1	
CRO	102/10:38 - 102/11:59		1	
GDSW	102/06:13 - 102/07:52		1	
ACN	102/14:09 - 103/01:38		1	
HSKW	102/12:01 - 104/13:14		1	
MIL	102/17:31 - 103/03:56		1	
GYM	102/19:35 - 103/03:56		1	
ETC	102/18:08 - 103/00:31		1	
HAW	102/23:34 - 103/03:36		1	
MADW	102/21:13 - 103/23:02		1	
MADW	102/23:14 - 103/01:59		1	
GDSW	103/04:22 - 103/08:44		1	
CRO	103/06:51 - 103/16:59		1	
HSKW	103/13:13 - 103/13:59		1	
ACN	103/14:53 - 104/01:37		1	
ETC	103/17:36 - 104/06:54		1	

TABLE 2.4 (Continued)

Apollo 13 C- and S-Band S-IVB Data from TLI to Impact - Cont.

Site	Tracking Period (GMT)		Down Link Frequency*	Comments
	Range Rate	Range		
HAW	103/23:49 - 104/06:17		1	
MIL	103/17:54 - 104/03:50		1	
MADW	103/21:14 - 103/22:09		1	
GDSW	103/22:47 - 104/02:04		1	
GWM	104/03:50 - 104/04:57		1	
HSK	104/07:00 - 104/09:00		1	
MAD	104/12:53 - 104/13:17		2	
ETC	104/19:26 - 105/21:56		11	
GDS	104/20:33 - 105/21:56		1	
ETC	104/21:56 - 105/01:12		2	
GDS	104/21:56 - 105/01:12		2	

*Frequency 1 - 2101.802112 MHz (Nominal)

Frequency 2 - 2101.859520 MHz (Offset)

TABLE 2.5 APOLLO 13 S-IVB IMPACT TIME*

Site	Date	GMT (Hr:Min:Sec)
HAW	April 15	01:09:39.686
ACN		01:09:39.700
GDS		01:09:39.700
MAD		01:09:38.689
MIL		01:09:39.706
ETC		01:09:39.689

*Impact times based upon rf signal loss and corrected for propagation delay.

TABLE 2.6 APOLLO 13 S-IVB POST-MISSION ANALYSIS (1-PER-MINUTE DATA)

Site	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)	Mean $\dot{R}$ Residuals (mm/sec)	1σ R Noise (mm/sec)	Mean R Residuals (meters)
	0 (12/02:00 - 12/07:00)			1 (12/15:00 - 13/04:22)			2 (13/04:23 - 13/20:00)[b]			3 (13/20:01 - 14/10:30)[a]		
MADW				-7.5	86.7	82	-5.2	99.4				
ACN				2.2	87.7		2.9	98.4		13.5	94.8	
GWM	12.1	20.1		25.6	80.7					11.3	99.2	
MIL	-1.4	11.7		6.3	89.2		6.3	98.0		3.5	99.6	
ETC	3.2	11.8		5.7	87.9		2.3	98.6		19.0	96.3	
GYM				6.9	89.0							
GDSW	-2.9	11.6	13	-2.3	89.9	-233				-.5	100.1	1
HAW	14.7	9.8		0.0	92.0		4.3	99.3		.3	100.6	
HSKW	-17.2	12.8	-21				-.5	95.4	-8			
CRO							1.0	96.4				
GDS										11.4	98.4	
HSK										-5.3	99.0	
TEX	-5.2	10.7										
BDAQ C-Band			37									
MILT C-Band			-29									
	4 (14/10:30 - Impact)			12 (12/15:00 - 13/20:00)[b]			23 (13/04:23 - 14/10:30)[a,b]			34 (13/20:01 - Impact)		
MADW				-5.8		93		-3.3				
ACN				4.2				4.9				
GWM				32.0				2.4		-1.6		
MIL				4.7				5.1		-3.1		
ETC	-3.3	108.3		4.1				11.1		1.1		
GYM				5.8								
GDSW				-4.7		-180		-5.2	-93	-5.7		33
HAW				2.0				2.6		-7.9		
HSKW				-.2		-497		2.1	1453			
CRO				1.6				4.2				
GDS	-.6	109.8						18.7		-1.2		
HSK	-.3	102.7						10.6		6.4		
MAD	1.2	105.1								2.5		

TABLE 2.6 (Continued)

Apollo 13 S-IVB Post Mission Analysis (1-Per-Minute Data) - Cont.

Site	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)	Mean $\dot{R}$ Residuals (mm/sec)	$1\sigma\dot{R}$ Noise (mm/sec)	Mean R Residuals (meters)
	123 (12/15:00 - 14/10:30)[a,b]			234 (13/04:23 - Impact)[a,b]			1234 (12/15:00 - Impact)					
MADW	-1.6		44	1.1			Not Available at Time of Pulbication					
ACN	3.6			3.7								
GWM	9.0			.4								
MIL	7.8			10.7								
ETC	9.4			2.9								
GYM	5.6											
GDSW	-4.6		-63	1.8		-76						
HAW	4.4			4.5								
HSKW	7.7		350	-.2		2163						
CRO	10.2			3.1								
GDS	25.6			-2.9								
HSK	-12.3			14.5								
MAD				-1.0								

[a]All data from 13/20:00 - 21:14, 13/22:24 - 14/02:04 and all MADW not used in BET.

[b]All data from 13/04:33 to 13/05:39 not used in BET.

TABLE 2.7 APOLLO 13 S-IVB IMPACT PARAMETERS BASED UPON VARIOUS INTEGRATED BET'S
(All BET's used 60 sec Data Interval)

Arc	GMT (Day/Hr:Min:Sec)	Selenog.[a] Lat. (Deg)	Selenog.[a] Long. (Deg)	Velocity (Km/sec)	Flight Path Angle (Deg)	Day	Impact GMT (Hr:Min:Sec)
0	12/02:00 - 07:00:00	-6.806	-30.29	2.58	-78.27	April 15	01:02:55
1	12/15:00 - 13/04:22	-1.936	-28.45	2.58	-76.61		01:09:51
2	13/04:30 - 13/20:00	-2.829	-28.08	2.58	-76.47		01:09:37
3[b]	13/20:01 - 14/10:30	-2.406	-26.12	2.58	-75.06		01:08:36
4f[c]	13/10:31 - Impact	-2.730	-27.87	2.58	-76.32		01:09:39
4[d]	14/10:31 - Impact	-2.838	-27.86	2.58	-76.32		01:09:39
5	14/21:54 - Impact	-2.954	-27.86	2.58	-76.34		01:09:30
12	12/15:00 - 13/20:00	-2.767	-28.46	2.58	-76.75		01:09:51
23	13/04:30 - 14/10:30	-2.373	-27.10	2.58	-75.73		01:09:06
34	13/20:01 - Impact	-1.954	-27.96	2.58	-76.28		01:09:39
123	12/15:00 - 14/10:30	-2.173	-27.51	2.58	-76.00		01:09:19
234	13/04:30 - Impact	-2.113	-27.97	2.58	-76.31		01:09:39
1234	12/15:00 - 13/04:22	Not Available at Time Of Publication					

[a]Negative Latitude - South, Negative Longitude - West

[b]All data from 13/20:00 - 21:14 and all MADW data from 13/22:24 - 14/02:04 not used in BET construction.

[c]All ETC 3-way data from 19:26 to 21:56 and all GDS 3-way data from 20:33 to 21:56 was not used in BET construction. (16% less data than in Arc 4).

[d]No data missing.

TABLE 2.8 ORAN SIMULATION RESULTS
(for the period from 12/01:17 to 12/14:42)

ORAN Run	Description of Run	1 Sigma Uncertainties				Bias	Noise
		Noise Only*		Noise + Bias			
		(Km)	(Sel. Deg.)	(Km)	(Sel. Deg.)		
1	All 2-way, All 3-way	1.8	.06	3.0	.10	2-way freq = 0	Range = 5 meters
2	Omitted MADW 2 & 3-way	3.8	.12	6.9	.23	3-way freq = 1.5 mm/sec (approx. 1 part 10^{11})	Range rate = 12mm/sec***
3	Omitted HSKW 2 & 3-way	3.6	.12	6.3	.21	Range = 20 meters**	
4	Omitted GDSW 2 & 3-way	3.2	.10	5.0	.17	CRO, HAW, GWM Geodetic = 40 meters	
5	GDSW 2 & 3-way only	9.6	.32	17.4	.58	HSKW, MADW Geodetic = 30 meters	
6	HSKW 2 & 3-way only	7.2	.24	12.3	.41	MIL, ETC Geodetic = 20 m	
7	MADW 2 & 3-way only	54.4	1.81	59.1	1.97	GDSW, TEX Geodetic = 10 m	
8	All 2-way	3.4	.11	4.0	.13		
9	GDSW & HSKW 2-way only	13.2	.44	13.3	.44		
10	GDSW 2-way only	1516.0	50.53	1516.0	50.53		

*3Km = .1 selenographic degree

**Only one range used at the beginning of each 2-way site interval

***Sampling interval of 60 seconds used throughout. Major source of range rate noise simulated is caused by USB equipment quantizing.

TABLE 2.9 ORAN SIMULATION RESULTS
(for the period from 12/14:50 to Impact)

Arc	1 Sigma Uncertainties				Bias	Noise
	Noise Only		Noise + Bias			
	(Km)	(Selenog. Deg)*	(Km)	(Selenog. Deg)		
1	56.4	1.88	57.5	1.92	2-Way freq = 0	Range = 5 meters
2	38.9	1.30	39.6	1.32	3-Way freq = 1.5 mm/sec (approx. 1 part in 10^{11})	Range rate = 96 mm/sec***
3	57.8	1.93	58.3	1.94	Range = 20 meters **	
4	12.2	.41	12.6	.42	CRO, HAW, GWM, ACN Geodetic = 40 meters	
12	14.9	.50	15.1	.50	MADW, HSKW, MAD, HSK Geodetic = 30 meters	
23	22.6	.75	23.1	.77	MIL, ETC Geodetic = 20 meters	
34	3.7	.12	5.2	.17	GDS, GDSW, Tex Geodetic = 10 meters	
123	2.9	.10	7.3	.24		
234	Not Available At Time Of Publication					
1234	.3	.01	2.4	.08		

*3Km = .1 selenographic degree
1 selenographic degree = 3 ± .05 Km

**Only one range used at the beginning of each 2-way site interval

***Sampling interval of 60 seconds used throughout. Major source of range rate noise simulated is caused by vehicle tumbling..

TABLE 2.10 GRTS IMPACT PREDICTIONS
(All Elements at 15/01:08 Epoch)

Arc	Selenographic			Data Sampling Interval (Sec)	MAD R Noise (mm/sec)
	Lat. (Deg)	Long. (Deg)	Flight Path Angle (Deg)		
		Arc Length From 14/21:54 to 15/01:08			
S1	-2.242	-27.919	-76.29	10	891
S2	-2.603	-27.855	-76.28	30	117
S3	-2.530	-27.939	-76.34	60	111
S4	-2.861	-27.784	-76.26	180	55
		Arc Length From 14/14:03 to 15/01:08			
S5	-2.080	-27.935	-76.27	20	513
S6	-2.768	-27.826	.31	30	112
S7	-2.379	-27.904	.29	40	177
S8	-2.428	-27.932	.32	60	106
S9	-2.724	-27.855	.29	180	60
		Arc Length From 14/09:16 to 15/01:08			
S10	-2.822	-27.863	-76.32	30	111
S11	-2.579	-27.920	.33	60	106
S12	-2.047	-27.835	.32	180	59

TABLE 2.11 COMPARISON OF REAL-TIME AND POST-MISSION ANALYSIS RUNS*

System	Selenographic			Data Points Used			MAD $\dot{R}$ Noise
	Lat. (Deg)	Long. (Deg)	Flt. Path Angle (Deg)	ETC	GDS	MAD	
			1-Per-10-Second Sample Rate				
RT System S1	-2.24	-27.92	-76.29	917	916	920	891
DEBTAP (Arc 6)	-2.65	-27.91	-76.34	1059	1110	1156	894
			1-Per-30-Second Sample Rate				
RT System S2	-2.60	-27.86	-76.28	305	305	299	117
DEBTAP (Arc 7)	-2.85	-27.86	-76.33	350	369	385	112
			1-Per-60-Second Sample Rate				
RT System S3	-2.53	-27.93	-76.34	148	149	145	111
DEBTAP (Arc 5)	-2.95	-27.86	-76.34	175	184	192	106

*Trajectory span = 14/21:54 to 15/01:08. All elements at 15/01:08 epoch.

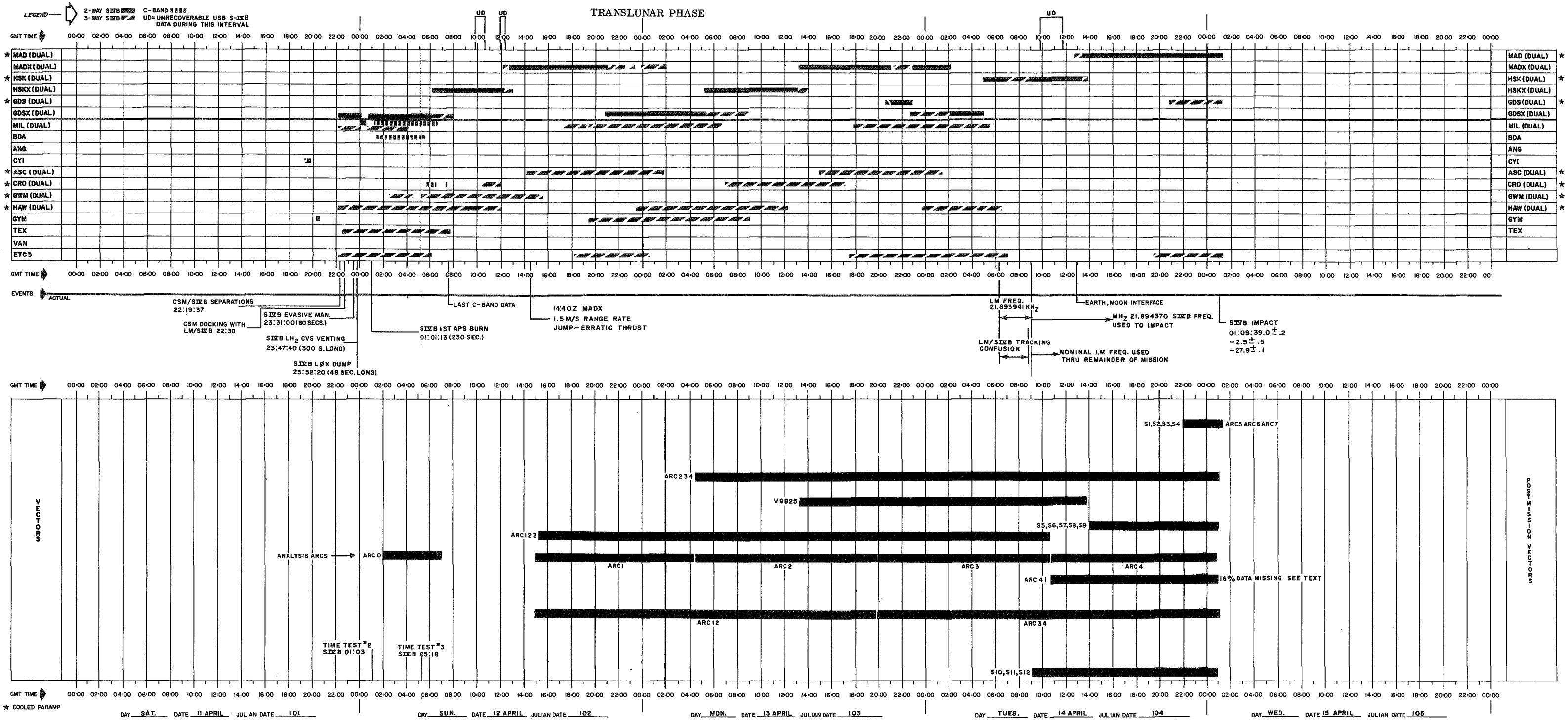


FIGURE 2.1 TRANSLUNAR TRACKING COVERAGE SUMMARY

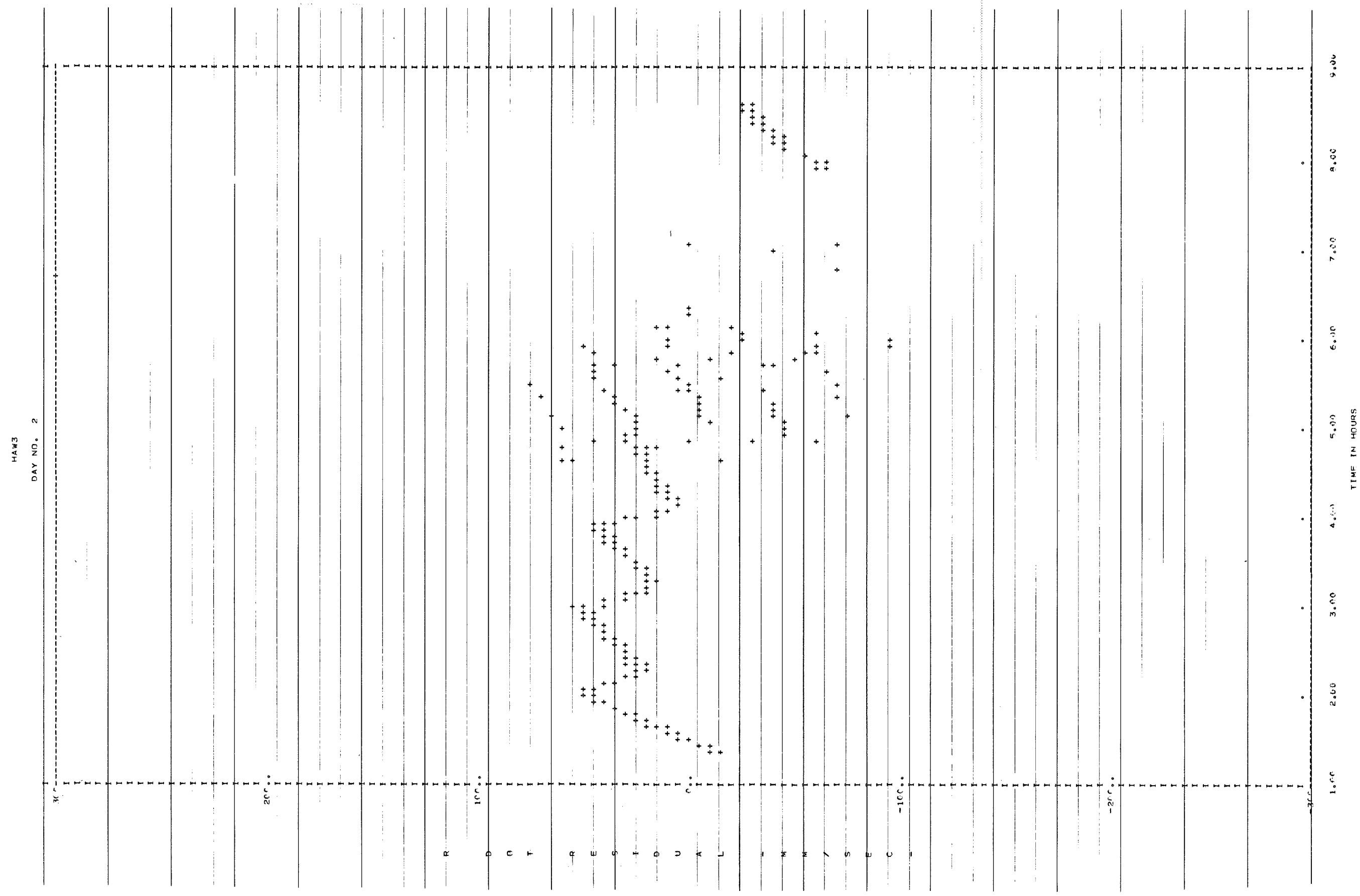


FIGURE 2.2 HAW3 RANGE RATE RESIDUALS VERSUS GMT (APRIL 12)

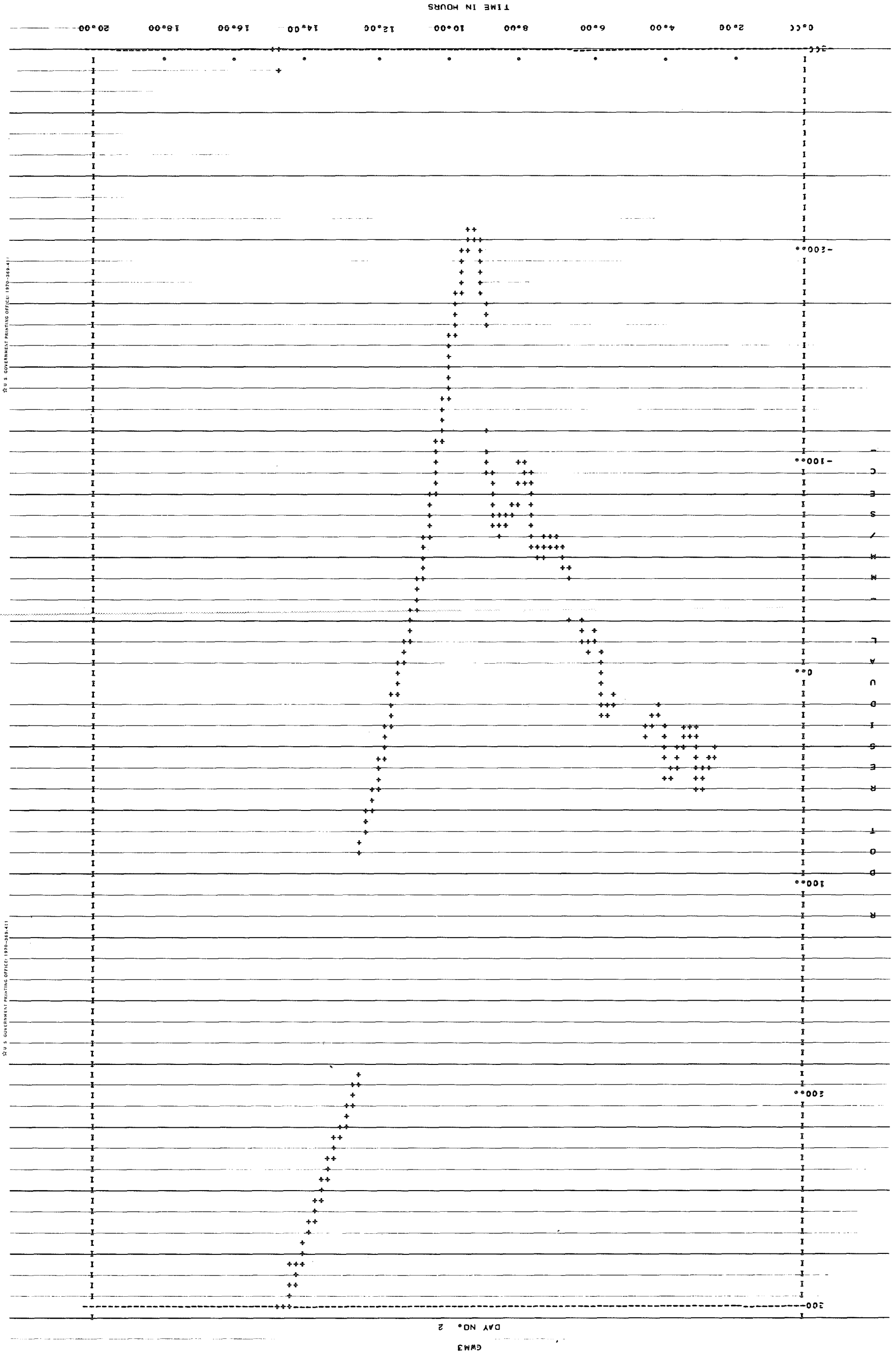


FIGURE 2.3 GWM3 RANGE RATE RESIDUALS VERSUS GMT (APRIL 12)

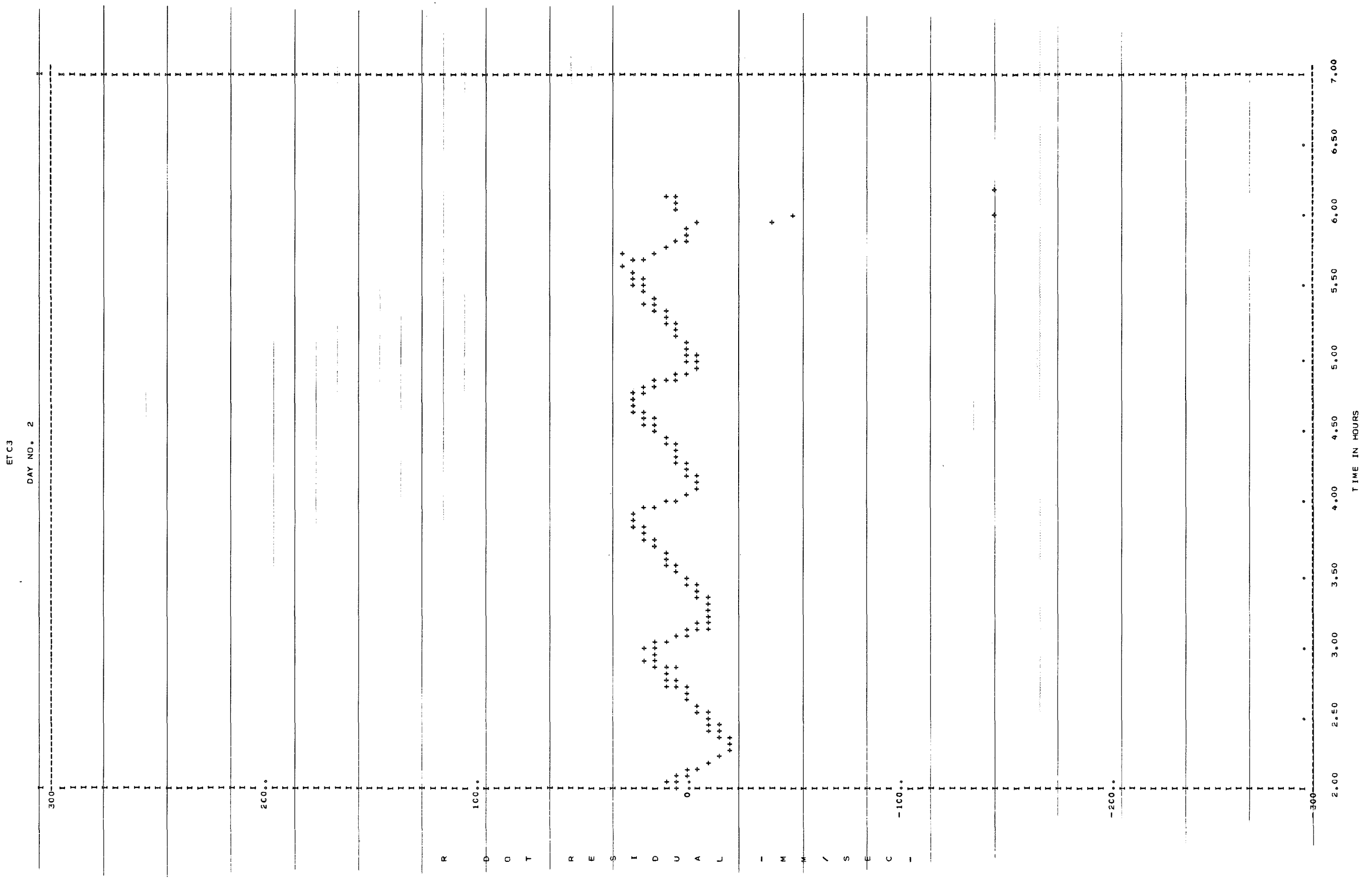


FIGURE 2.4 ETC3 RANGE RATE RESIDUALS VERSUS GMT (APRIL 12)

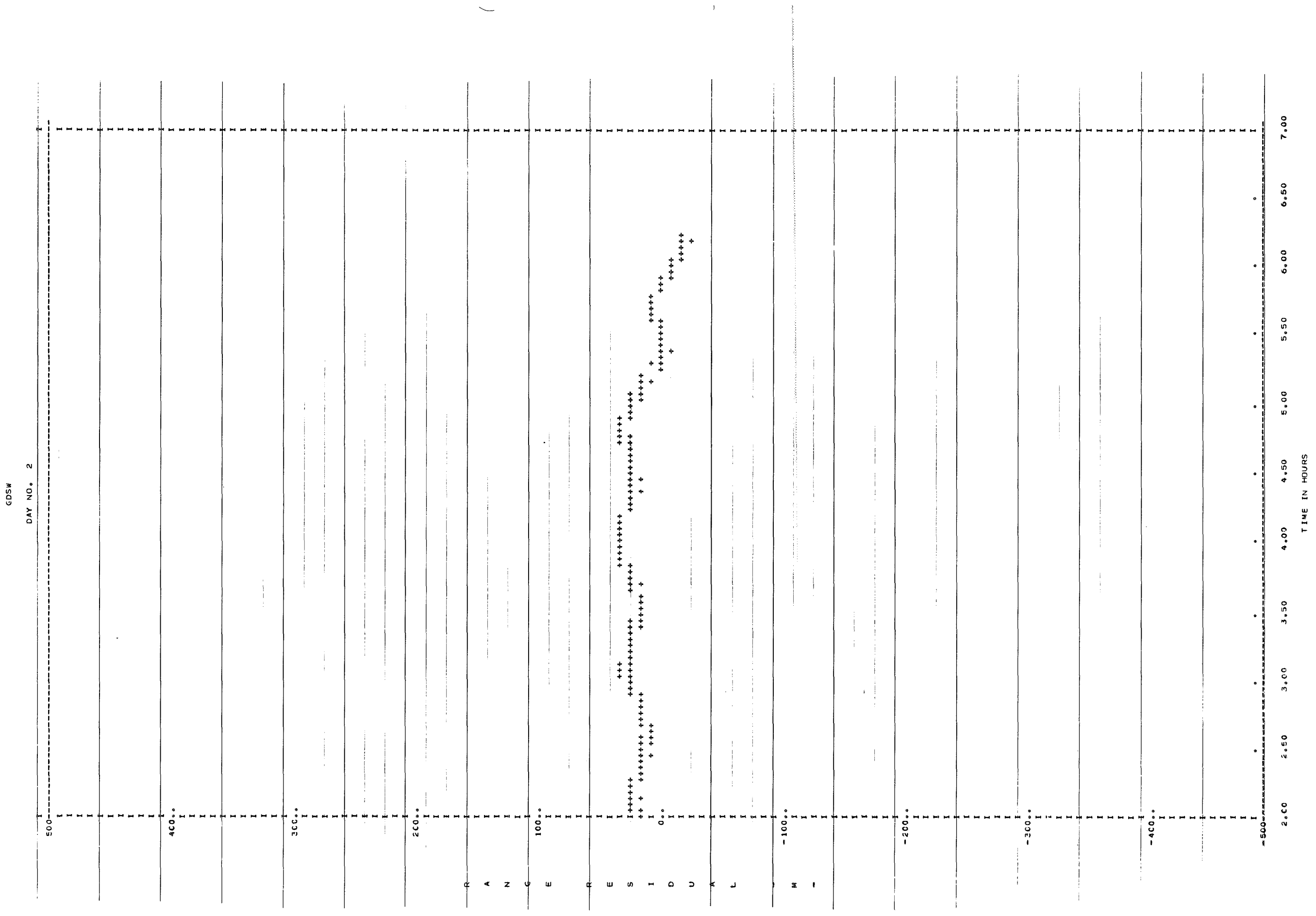


FIGURE 2.5 GDSW RANGE RESIDUALS VERSUS GMT (APRIL 12)

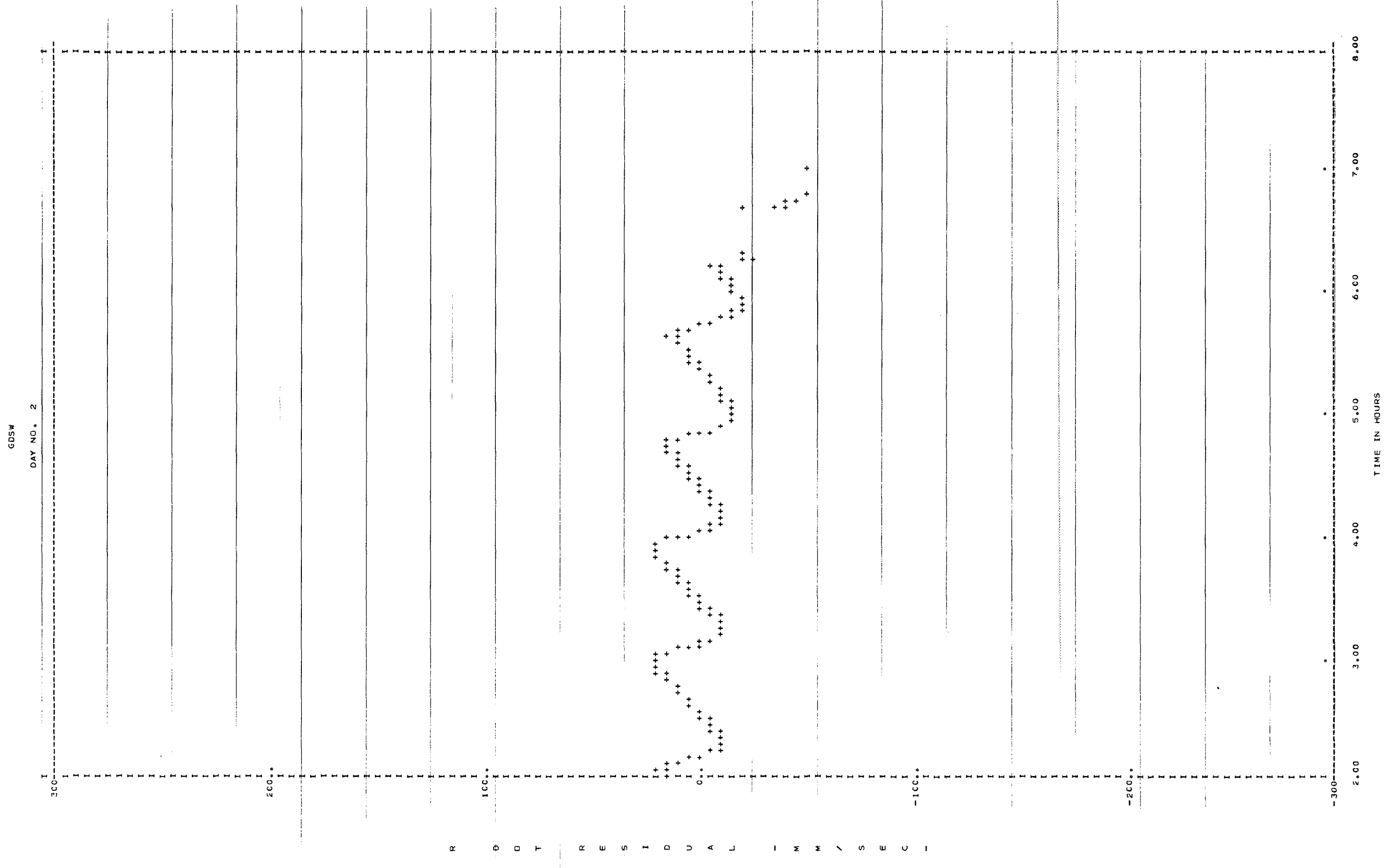


FIGURE 2.6 GDSW RANGE RATE RESIDUALS VERSUS GMT (APRIL 12)

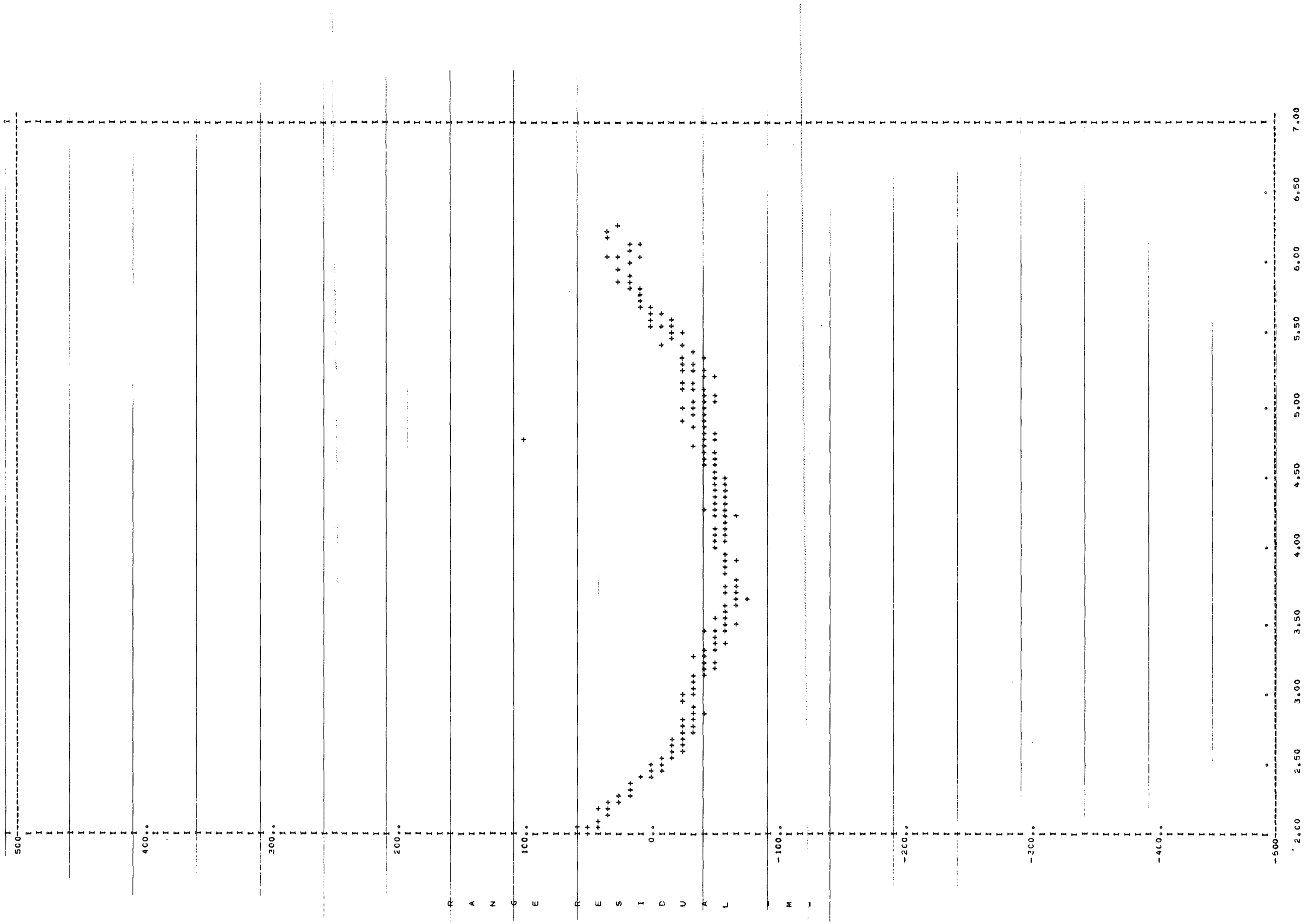


FIGURE 2.7 C-BAND MLAT RANGE RESIDUALS VERSUS GMT (APRIL 12)

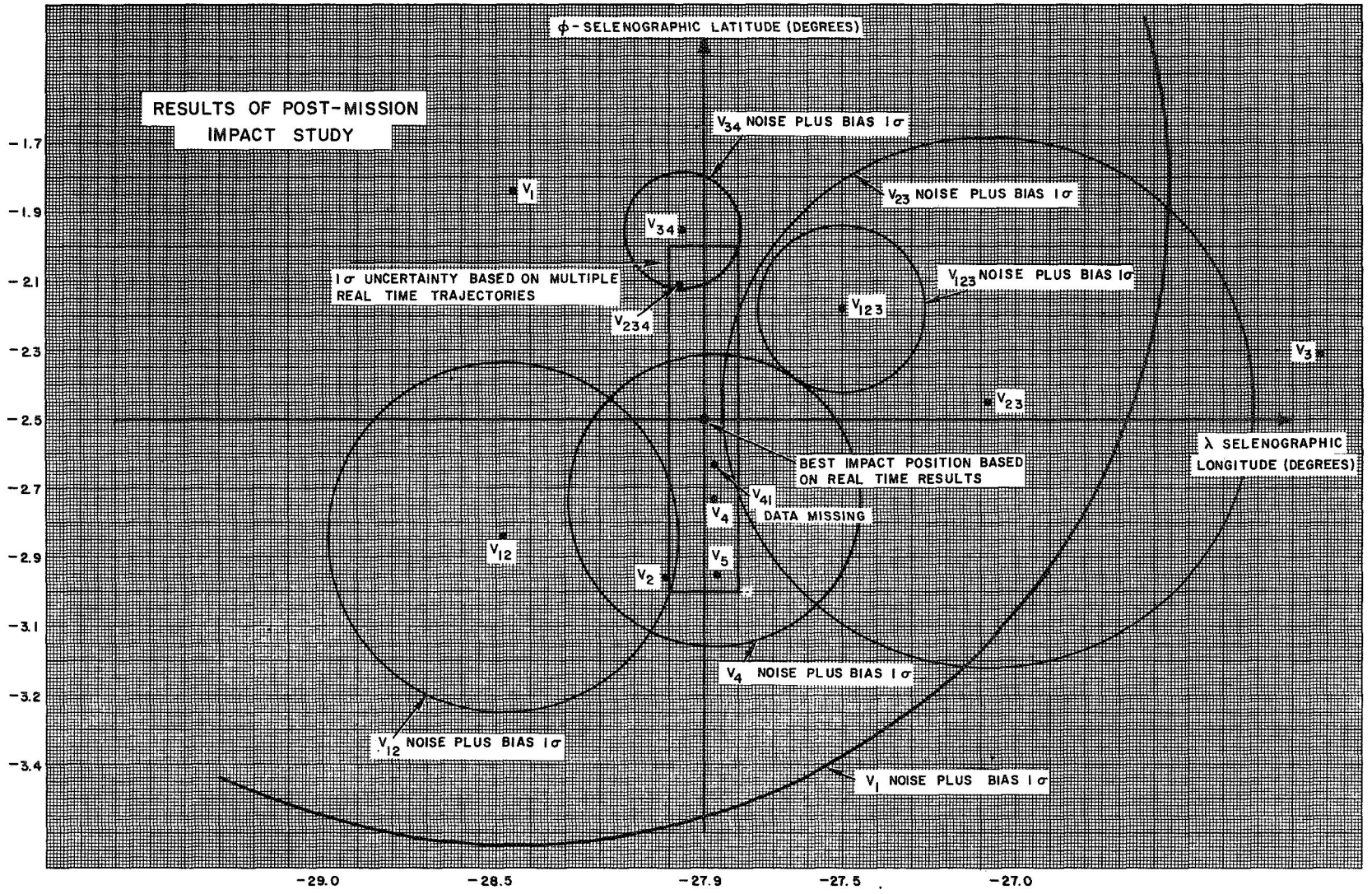


FIGURE 2.8 RESULTS OF POST-MISSION IMPACT STUDY

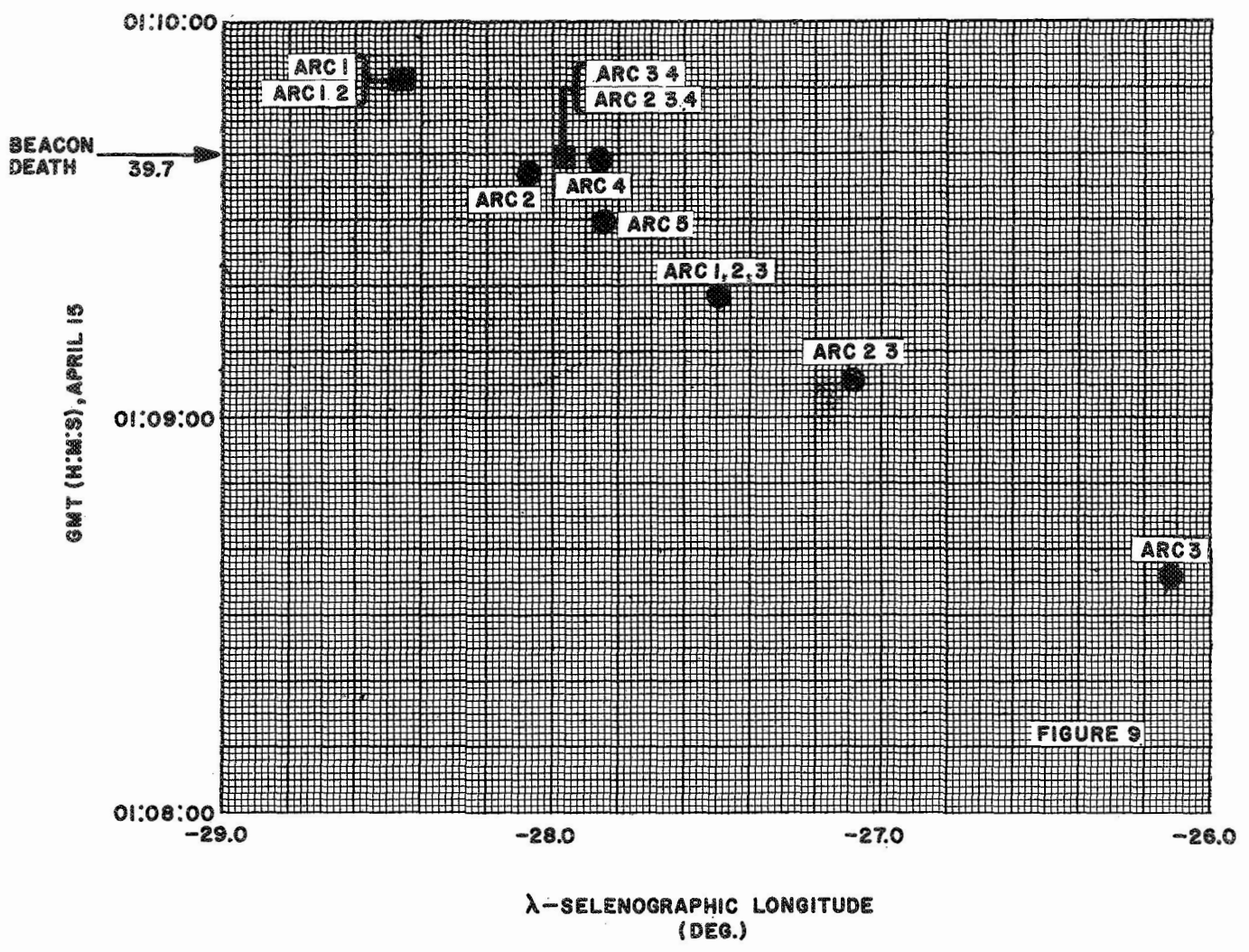


FIGURE 2.9 APOLLO 13 S-IVB IMPACT TIME VS IMPACT SELENOGRAPHIC LONGITUDE

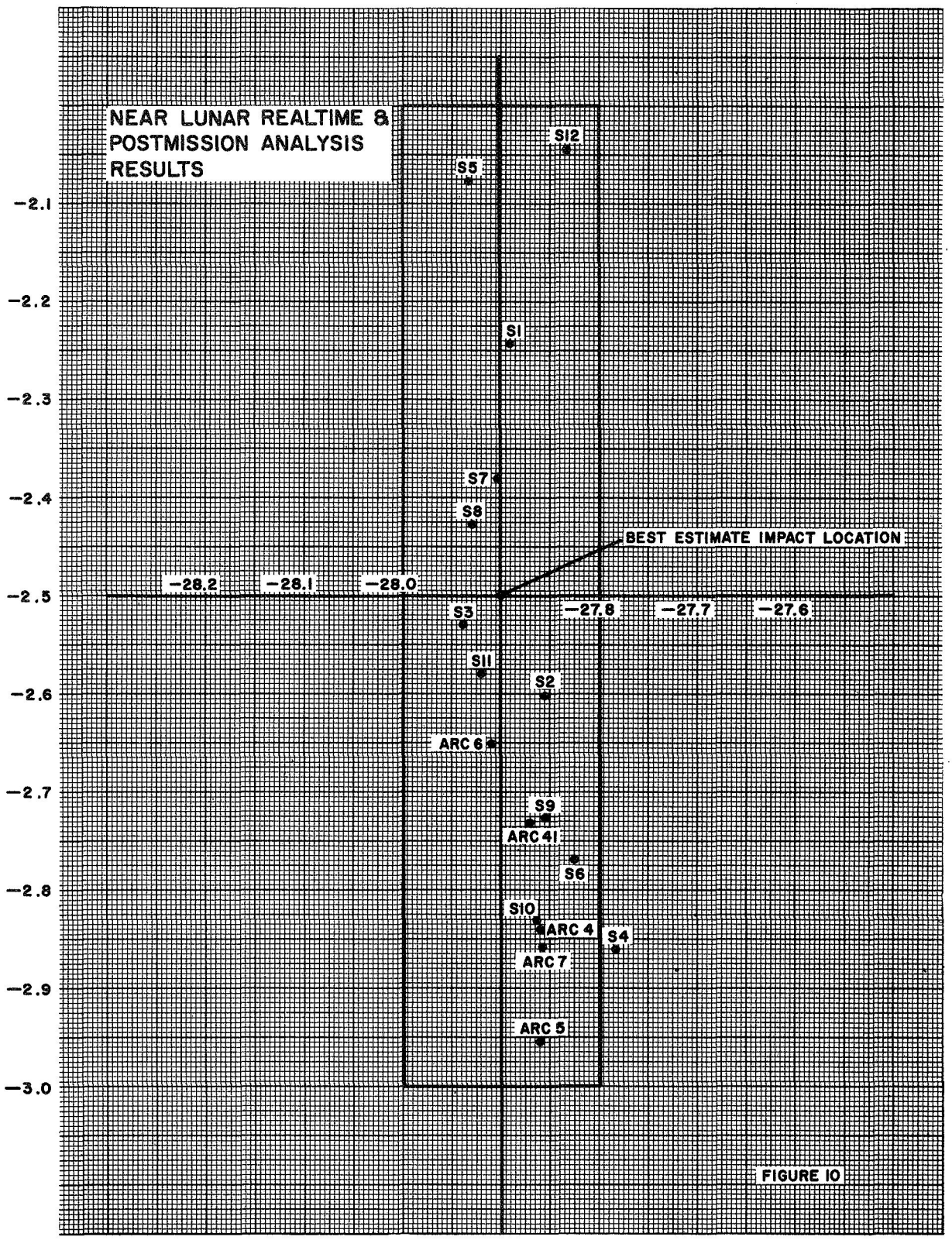


FIGURE 2.10 NEAR LUNAR REAL-TIME AND POST-MISSION ANALYSIS RESULTS

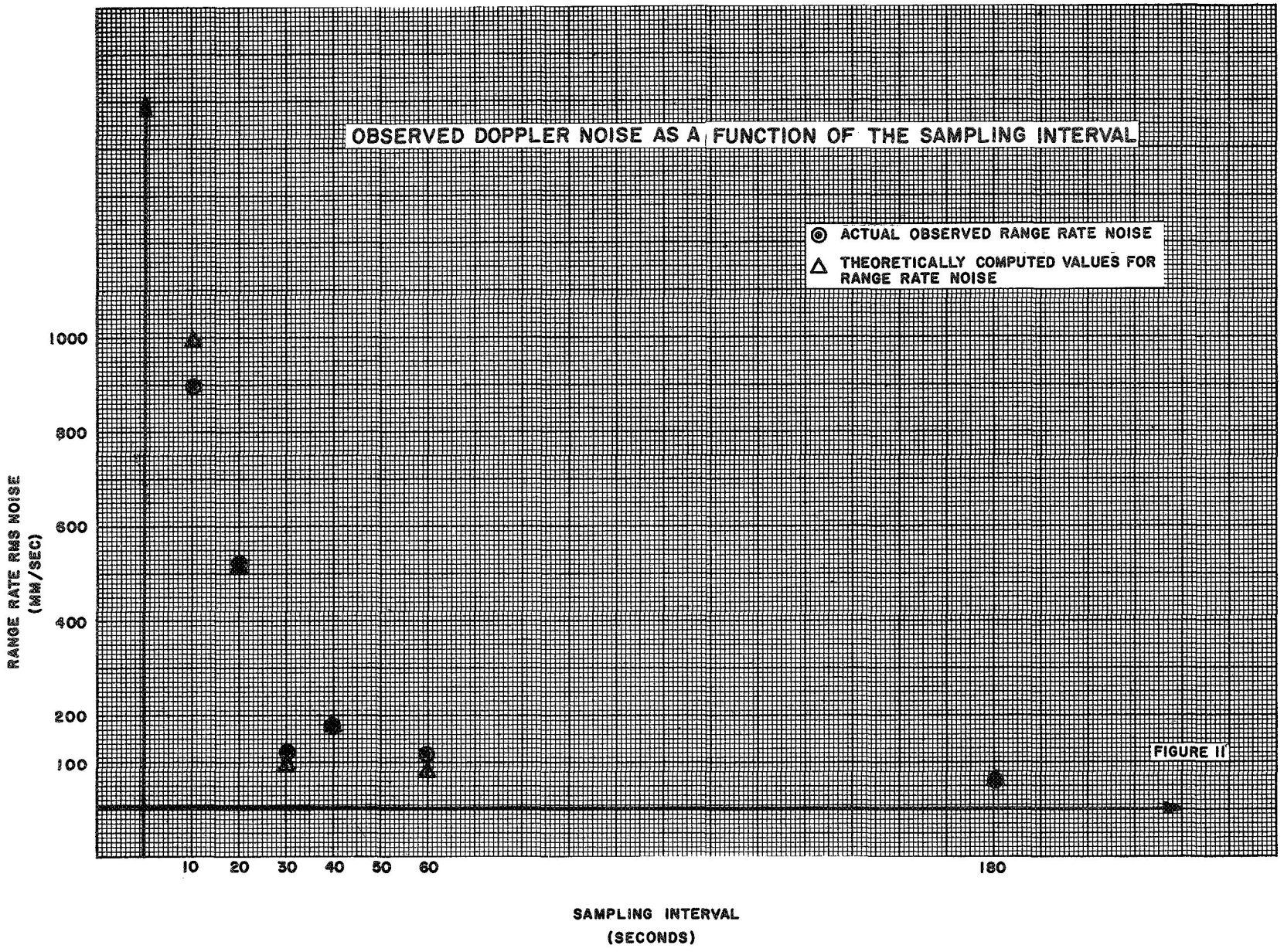


FIGURE 2.11 OBSERVED DOPPLER NOISE AS A FUNCTION OF THE SAMPLING INTERVAL

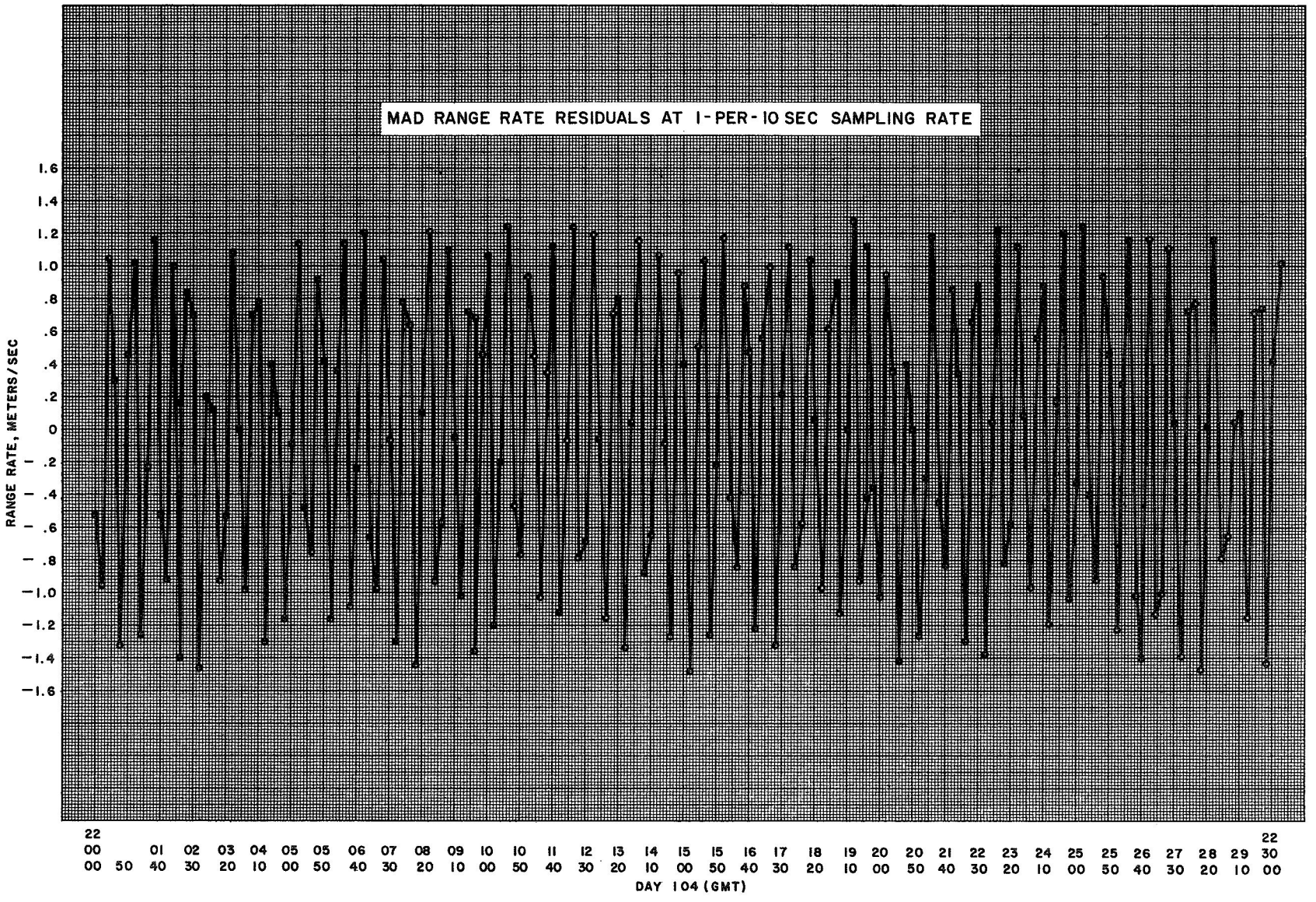


FIGURE 2.12 MAD RANGE RATE RESIDUALS AT 1-PER-10-SEC SAMPLING RATE

CHAPTER III. SPENT STAGE TRAJECTORY

By

W. D. McFadden

3.0 Trajectory Description and Impact Conditions

The AS-508 S-IVB/IU, LM and CSM were placed on a near nominal translunar trajectory at S-IVB/IU second cutoff. The translunar trajectory at first had the form of an ellipse with the center of the earth at one foci. The orbital parameters of the translunar trajectory conditions are given in 3.1. This ellipse was altered during Timebase 8 as described in Chapter I. The resulting orbital parameters of the new ellipse are presented in table 3.2.

As the S-IVB/IU moved nearer to the moon, its path was changed from elliptic to hyperbolic and terminated at lunar impact. Figure 3.1 is a geocentric spatial trace of the AS-508 translunar trajectory. Figure 3.2 shows a trace of the selenocentric subpoint of the vehicle from TLI to impact. Also shown are the selenocentric coordinate axes, subsolar point and subterrestrial point at time of impact.

The relative positions of various projected S-IVB/IU trajectories and CSM/LM trajectory are illustrated in figure 3.3. The Resultant S-IVB/IU Path After Evasive Burn represents the path which the vehicle would have followed after execution of the APS evasive burn if no further propulsive thrusting had occurred until impact. The other trajectories in figure 3.3 have similar significance.

Figure 3.4 provides a history of separation distance between the spacecraft and S-IVB/IU. The separation distance begins to increase at the time of the evasive burn.

Figure 3.5 and figure 3.6 present the earth-centered radius and velocity magnitudes, respectively, versus ground elapsed time, and figure 3.7 provides histories of the earth-probe-sun, sun-probe-moon, and earth-probe-moon angles during the translunar coast. Figures 3.8, 3.9, and 3.10 give histories of selenocentric altitude, velocity, and path angle and azimuth, respectively, near the moon and figure 3.11 shows a plot of earth referenced C_3 energy versus ground elapsed time near the moon prior to impact.

For the purpose of providing information for calculating the effective energy released, figure 3.12 presents the tangential and vertical velocity components at time of impact and table 3.3 summarizes actual impact conditions of the S-IVB/IU.

3.1 Trajectory Reconstruction

3.1.1 Reconstruction Prior to Anomalous Thrusting

A vector solution of tracking data arc 0, at a time of 15:00:00 GMT April 12 was integrated backward in time through the actual TB8 and TB7 impulses to CSM separation. The TB7 impulses which were modeled in the simulation were:

	ΔV, m/s	Pitch, deg	Yaw, deg
CSM/LM Ejection	-0.2	172	-40
CSM Separation	-0.1	138	-40

The negative velocity increments indicate that the impulse was directed along the S-IVB/IU negative longitudinal axis. The actual TB8 impulses and attitudes which were simulated are given in tables 1.2 and 1.4, respectively.

The trajectory print from 22:19:38.9 GMT April 11 to 38:42:10 GMT April 12 in subsection 3.2 was generated in this manner based on the tracking data in arc 0. For a discussion of data in arc 0 see Chapter II.

3.1.2 Reconstruction Following Anomalous Thrusting

The actual S-IVB/IU impact point was obtained by establishing the center of an envelope which enclosed all of the impact points resulting from the solutions of various combinations of tracking data arcs (see Chapter II). In addition, the actual impact time was obtained from the recorded termination time of the S-IVB/IU USB signal. There is no single data arc solution which produces the exact actual impact conditions. However, in order to present trajectory parameters which provide a good representation of the actual trajectory the solution vector based on arc 4 was used. The trajectory print in subsection 3.2 from 38:44:34 GMT April, termination of the anomalous APS thrusting, to lunar impact is based on the tracking data in arc 4.

Since the vector solution for arc 4 reflects data during the period from 10:31:00 April 14 to lunar impact, it was necessary to perform backward integration from near impact to the end of the anomalous APS thrusting in order to obtain a complete trajectory description. A complete discussion of the data in arc 4 is given in Chapter II.

TABLE 3.1 ORBIT PARAMETERS AT SPACECRAFT SEPARATION

PARAMETER	ACTUAL	NOMINAL	ACT−NOM.
SEMIMAJOR AXIS, km (n mi)	279,814 (151,100)	280,921 (151,697)	−1,107 (−597)
ECCENTRICITY	0.97645	0.97650	−0.00005
INCLINATION, deg	31.813	31.822	−0,009
C_3, m^2/s^2 (ft^2/s^2)	−1,424,527 (−15,333,482)	−1,418,914 (−15,273,064)	−5613 (−60,418)
RIGHT ASCENSION OF ASCENDING NODE, deg	350.107	350.173	−0.066
ARGUMENT OF PERIGEE, deg	324.290	329.276	−4.986
PERIGEE ALTITUDE, km (n mi)	212 (114)	224 (121)	−12 (−7)
APOGEE ALTITUDE, km (n mi)	546, 660 (295,196)	548,862 (296,385)	−2202 (−1,189)

*REFERENCED TO EARTH'S EQUATORIAL PLANE

TABLE 3.2 COMPARISON OF ORBIT PARAMETERS AFTER THE UNSCHEDULED DELTA V

PARAMETER	ACTUAL	NOMINAL	ACT–NOM
SEMIMAJOR AXIS, km (n mi)	266,092 (143,678)	267,411 (144,390)	–1319 (–712)
ECCENTRICITY	0.97585	0.97605	–0.00020
INCLINATION, deg*	31.8317	31.8498	–0.0181
C_3, m^2/s^2 (ft^2/s^2)	–1,497,990 (–16,124,162)	–1,490,600 (–16,044,617)	–7390 (–79,545)
RIGHT ASCENSION OF ASCENDING NODE, deg	350.1472	350.1475	–0.0003
ARGUMENT OF PERIGEE, deg	249.655	248.623	1.032
PERIGEE ALTITUDE, km (n mi)	47 (25)	25 (13)	22 (12)
APOGEE ALTITUDE, km (n mi)	519,381 (280,443)	522,040 (281,879)	–2659 (–1436)

*REFERENCED TO EARTH'S EQUATORIAL PLANE

TABLE 3.3 S-IVB/IU LUNAR IMPACT PARAMETERS

PARAMETER	ACTUAL VALUE AT IMPACT
STAGE MASS, kg (lbm)	13,971 (30,800)
MOON CENTERED SPACE-FIXED	
VELOCITY, kmls (n mi/s)	2,580 (1,372)
PATH ANGLE MEASURED FROM LOCAL VERTICAL, deg	13.6
HEADING ANGLE (NORTH TO WEST), deg	99.2
SELENOGRAPHIC WEST LONGITUDE, deg	27.9 ± 0.1
SELENOGRAPHIC SOUTH LATITUDE, deg	2.5 ± 0.5
IMPACT TIME, DAY/HR: MIN: SEC GMT	105/01: 09: 39.75±0.1
DISTANCE TO TARGET, km (n mi)	$65.5\ ^{+7.8}_{-4.8}$ $\left(35.4\ ^{+4.2}_{-2.6}\right)$
DISTANCE TO SEISMOMETER, km (n mi)	$139.1\ ^{+5.4}_{-3.8}$ $\left(75.1\ ^{+2.9}_{-2.1}\right)$

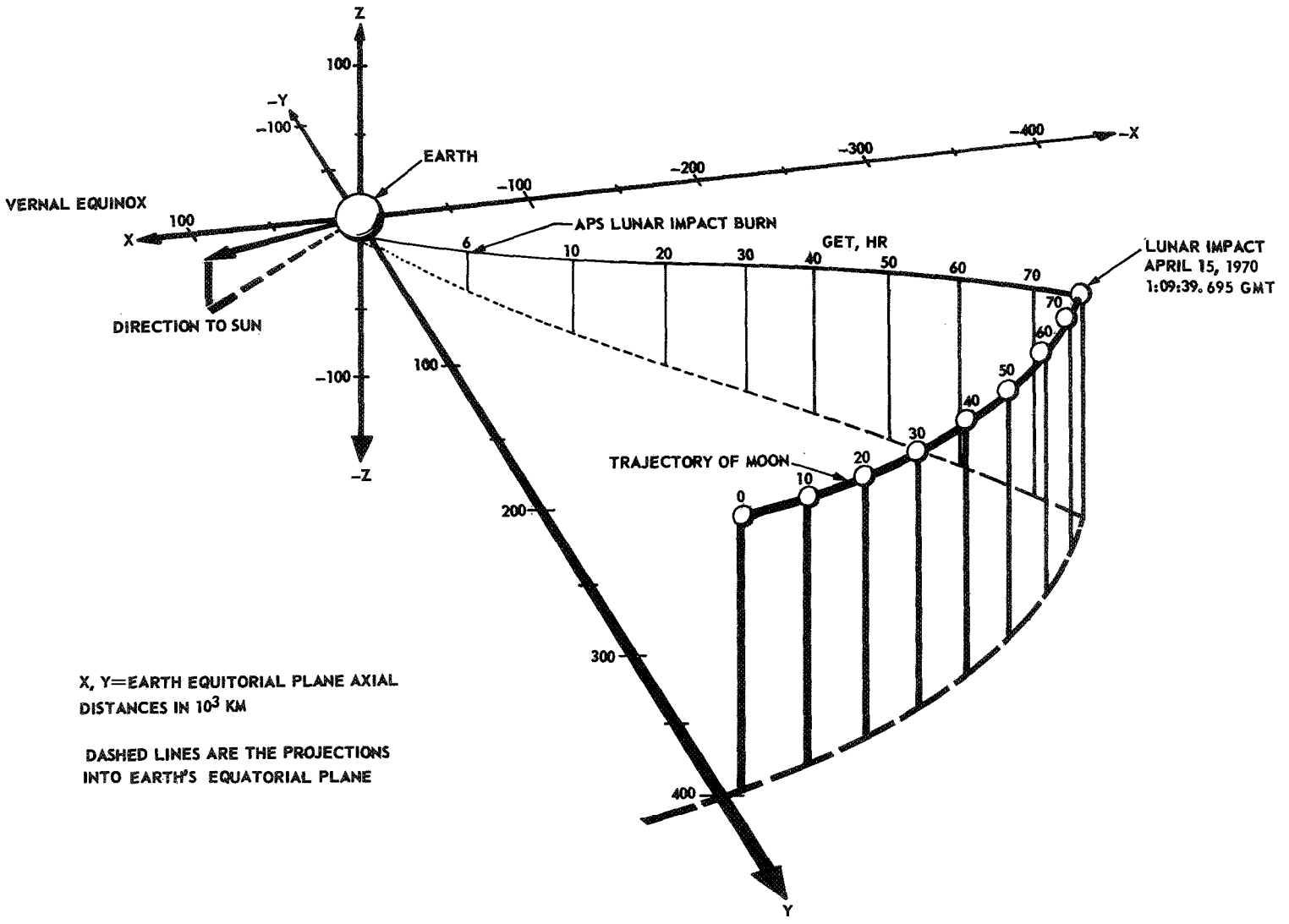


FIGURE 3.1 GEOCENTRIC SPATIAL TRACE

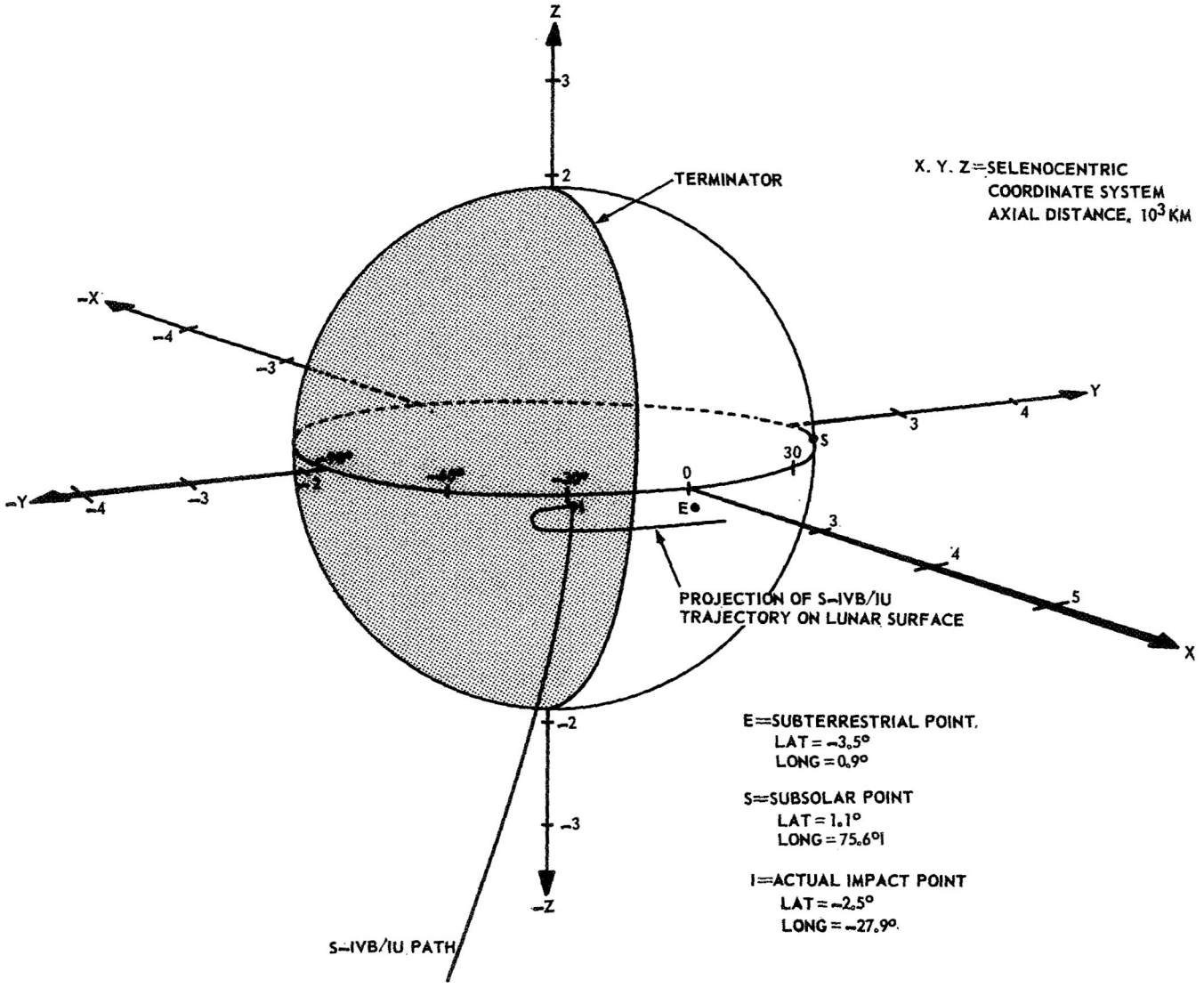


FIGURE 3.2 LUNAR SUBPOINT TRACE

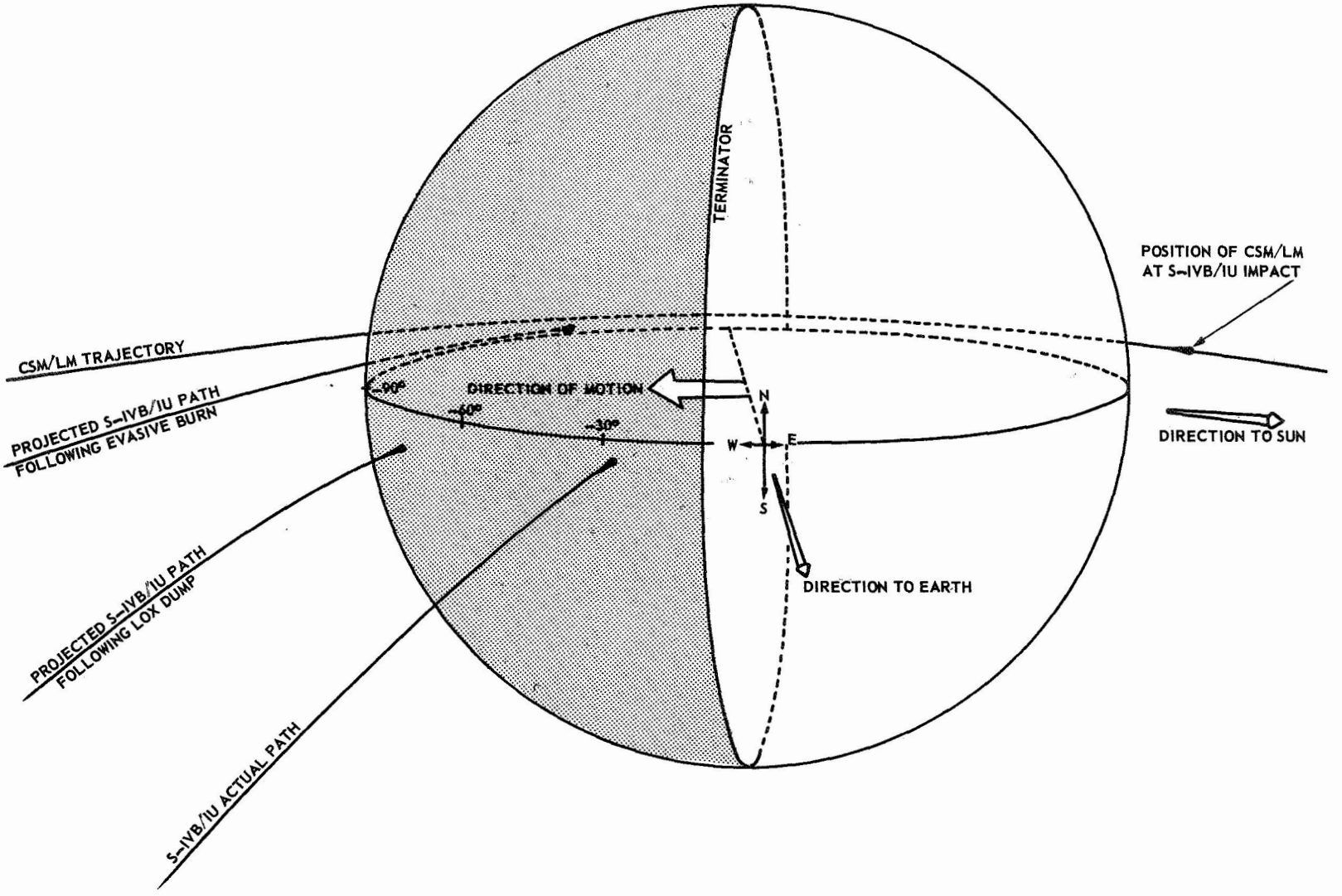


FIGURE 3.3 RELATIVE SPACECRAFT/S-IVB ARRIVAL LOCATIONS

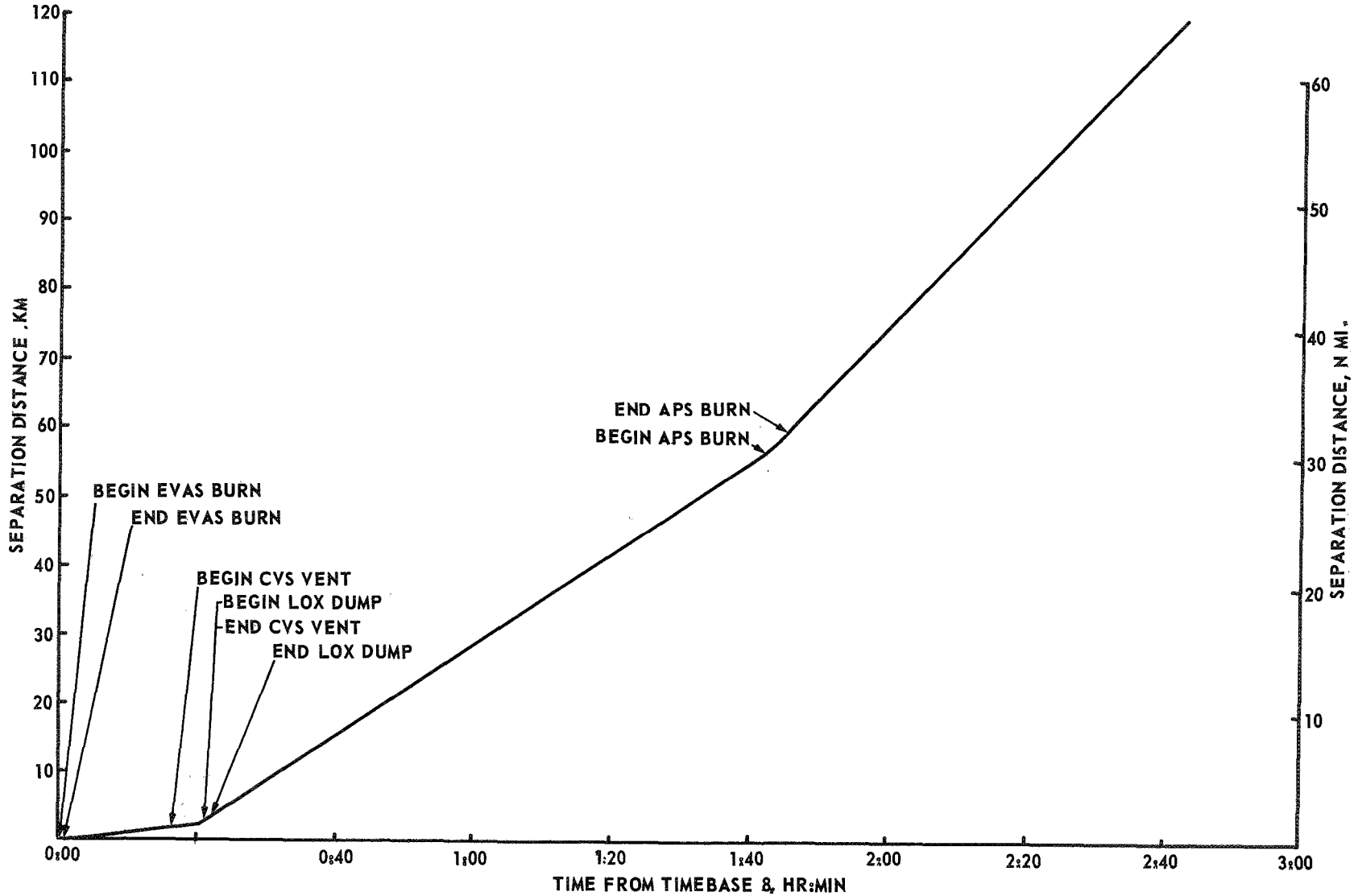


FIGURE 3.4 SPACECRAFT/S-IVB SEPARATION DISTANCE HISTORY

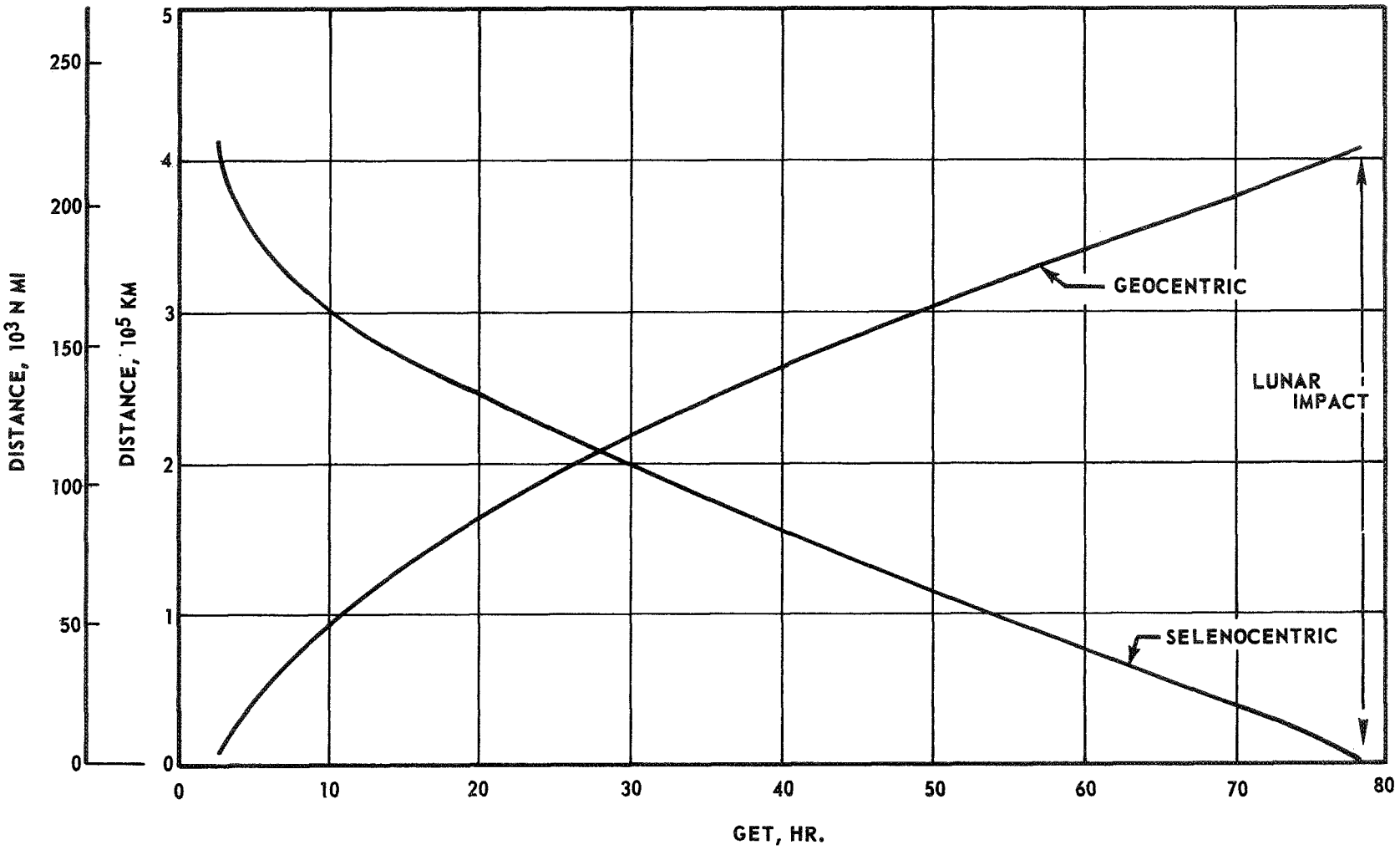


FIGURE 3.5 VEHICLE DISTANCE VS GROUND ELAPSED TIME

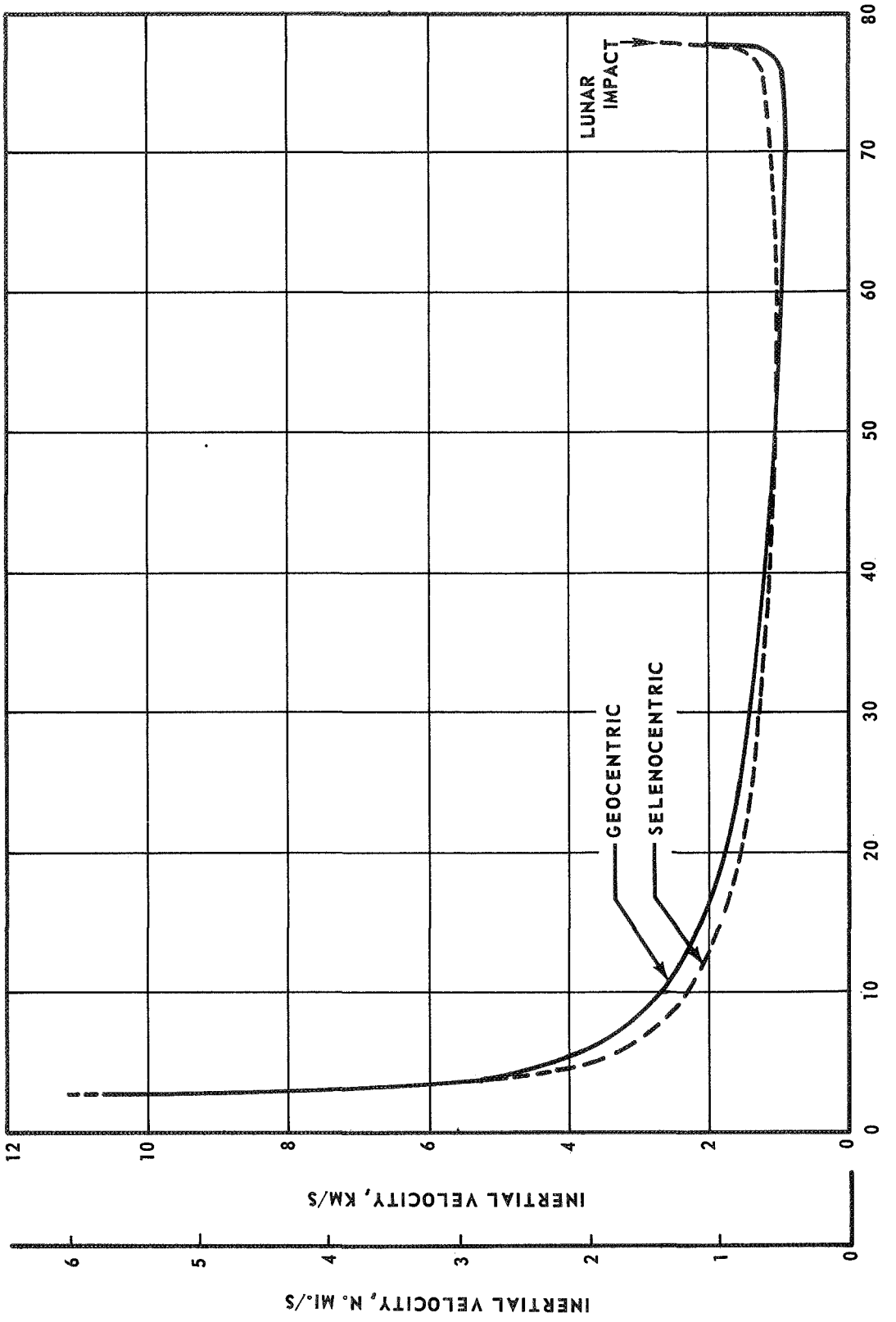


FIGURE 3.6 INERTIAL VELOCITY VS GROUND ELAPSED TIME

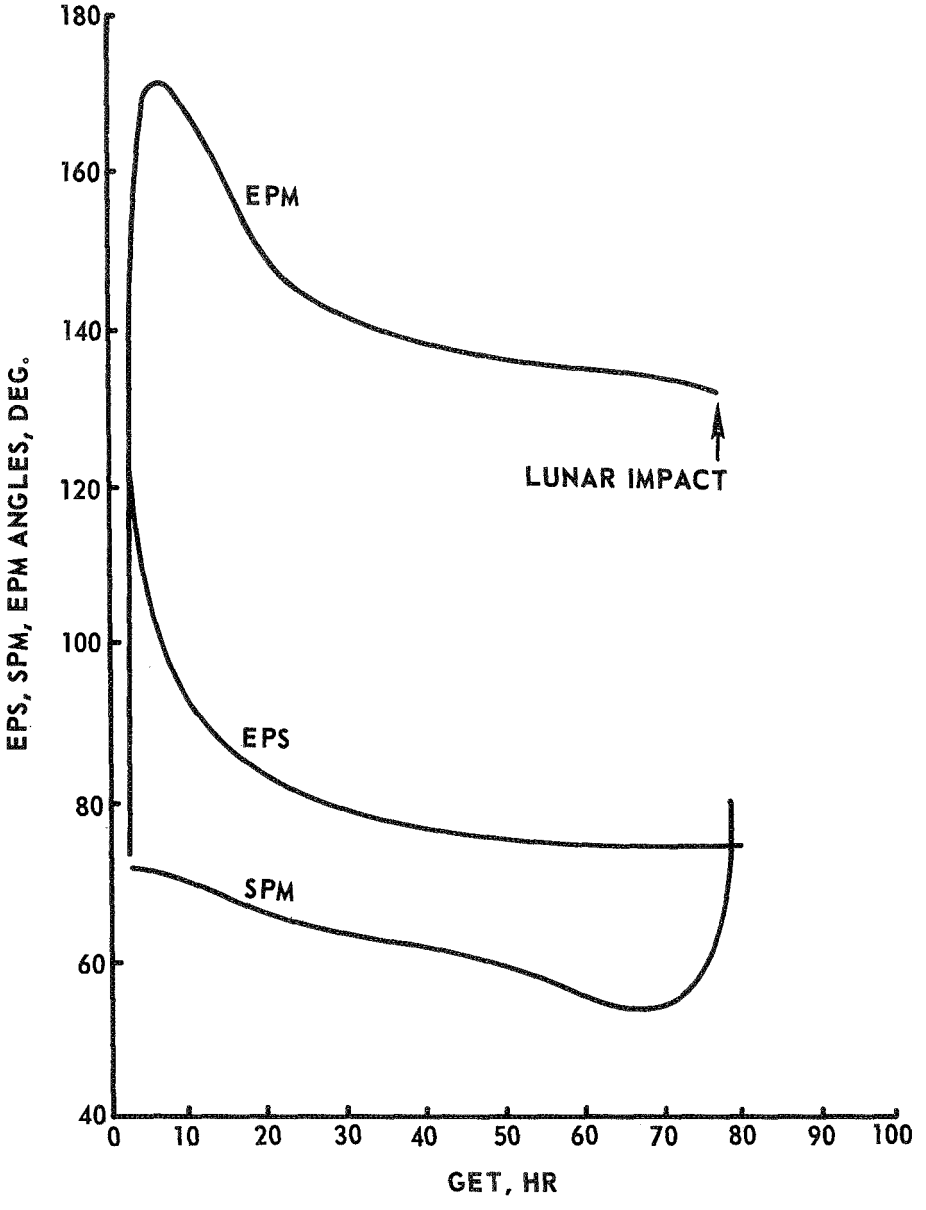


FIGURE 3.7 S-IVB/IU LINE-OF-SIGHT ANGLES

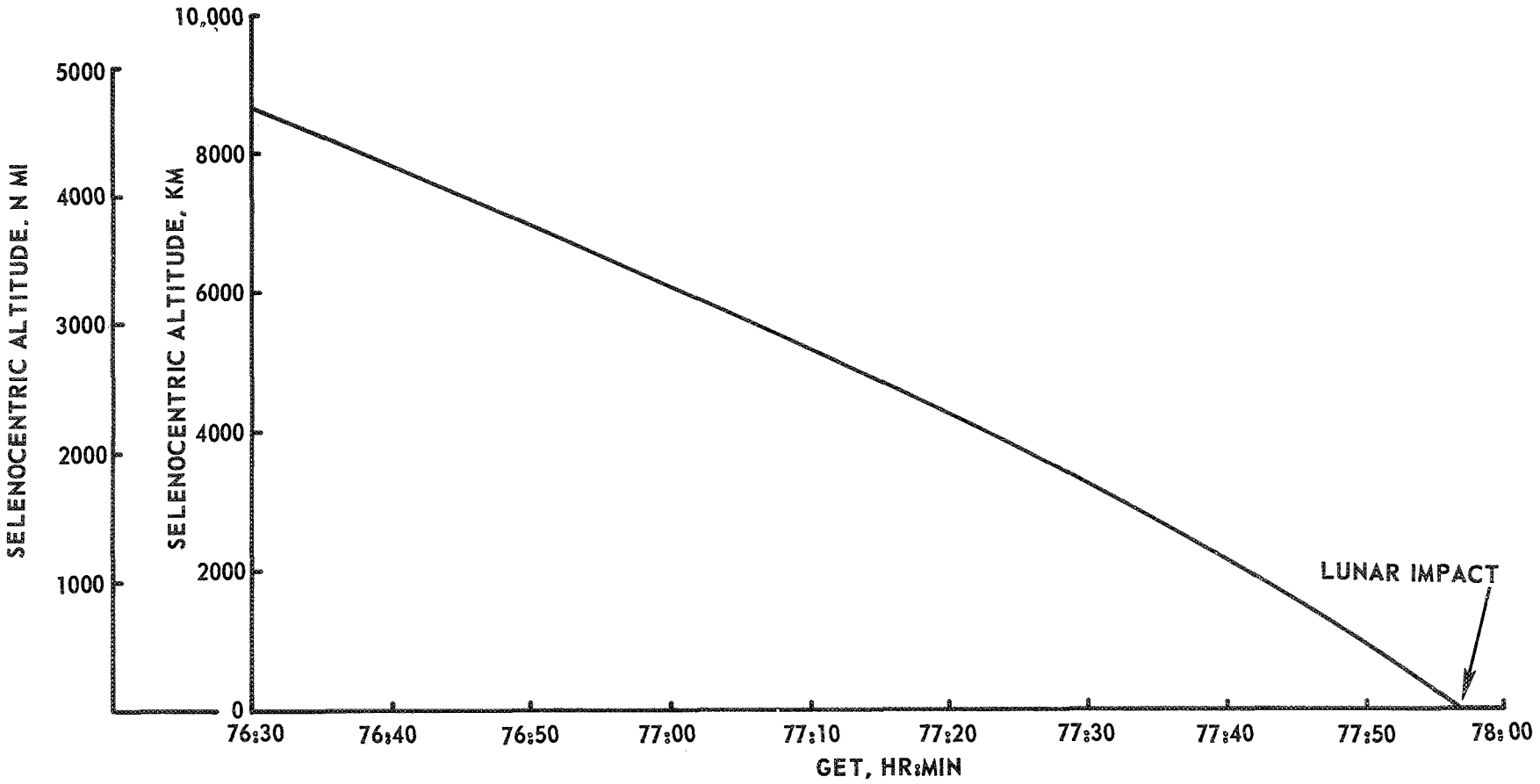


FIGURE 3.8 SELENOCENTRIC ALTITUDE VS GROUND ELAPSED TIME

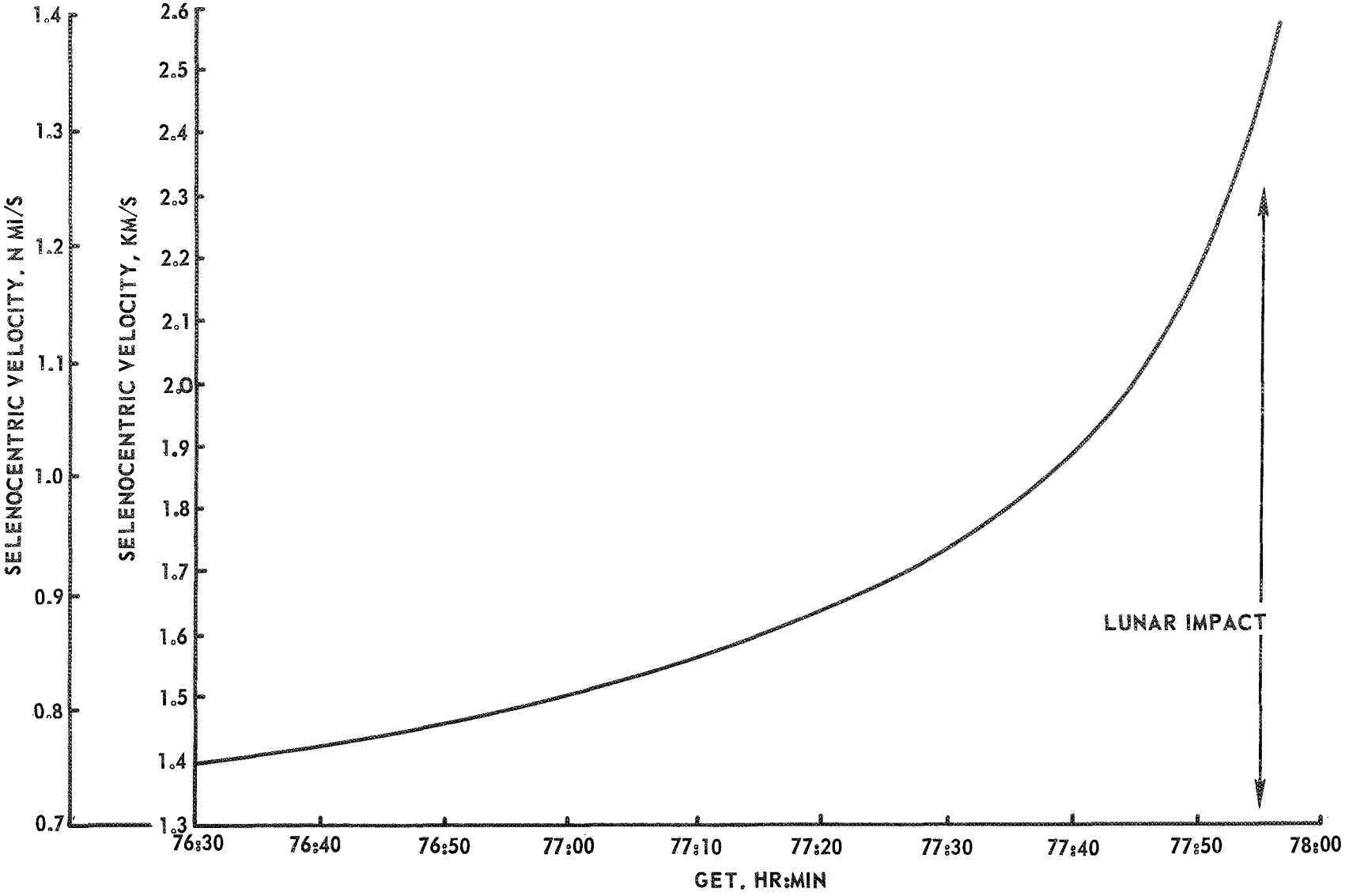
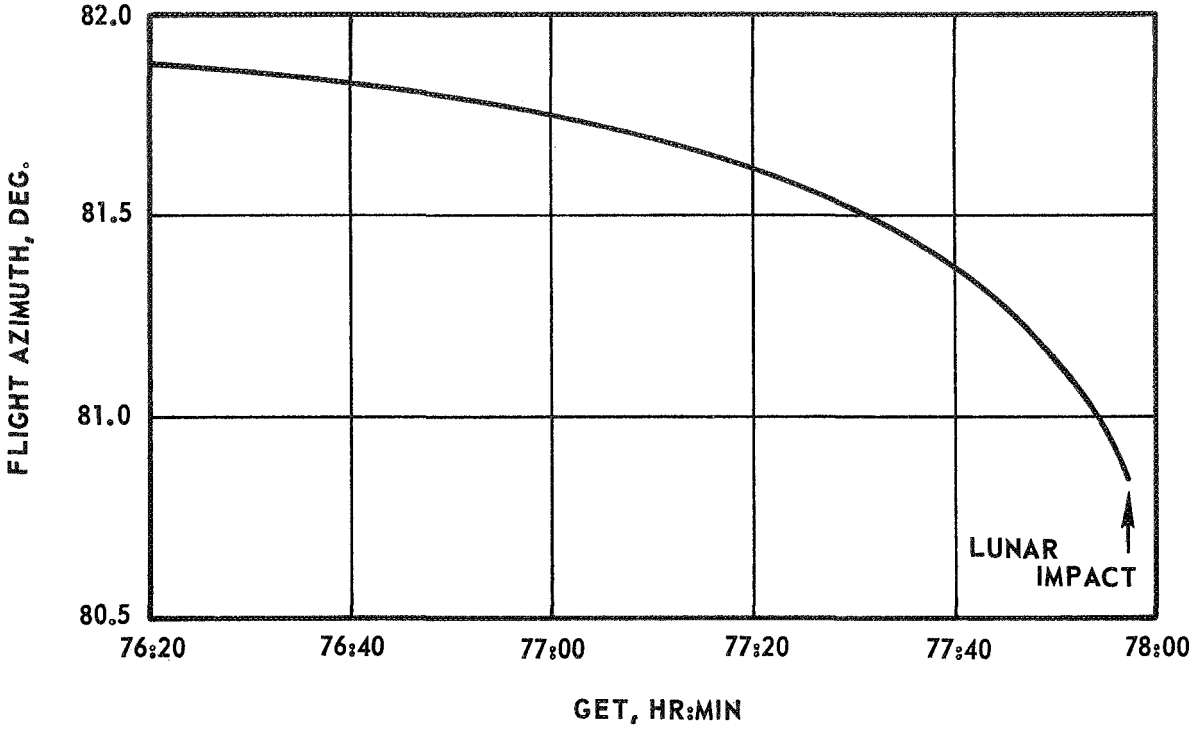


FIGURE 3.9 SELENOCENTRIC VELOCITY VS GROUND ELAPSED TIME



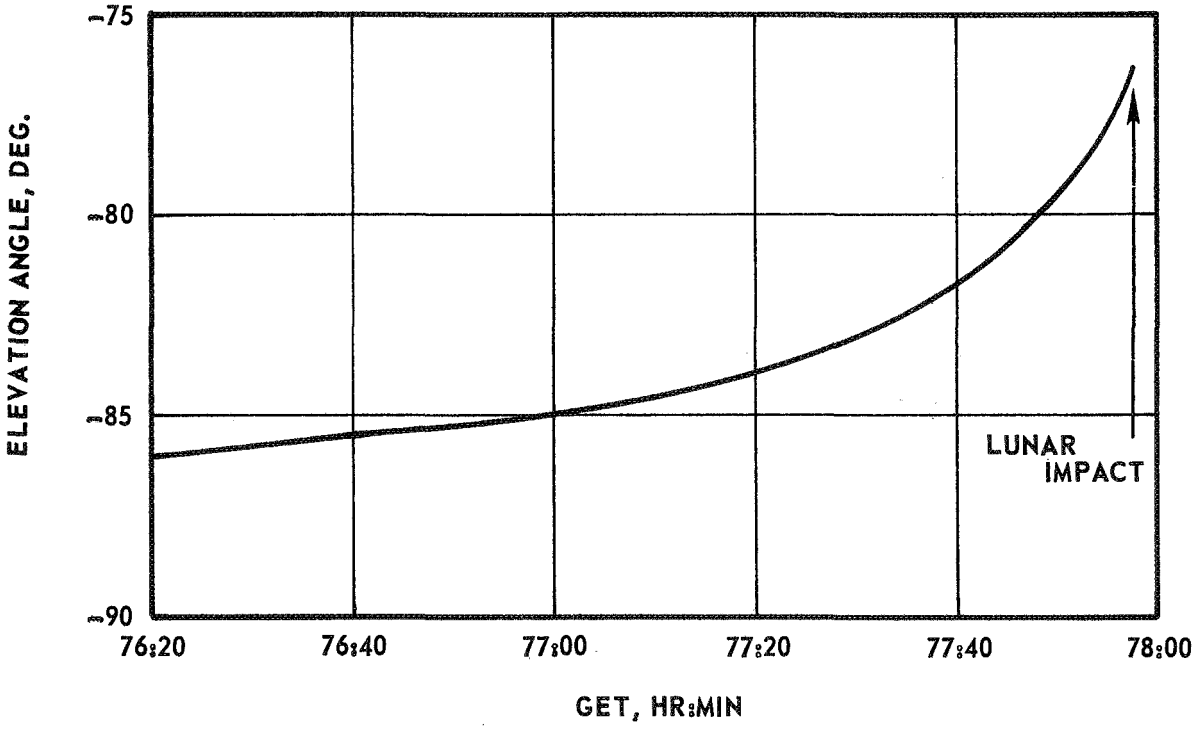


FIGURE 3.10 SELENOCENTRIC FLIGHT AZIMUTH AND ELEVATION OF VELOCITY VECTOR

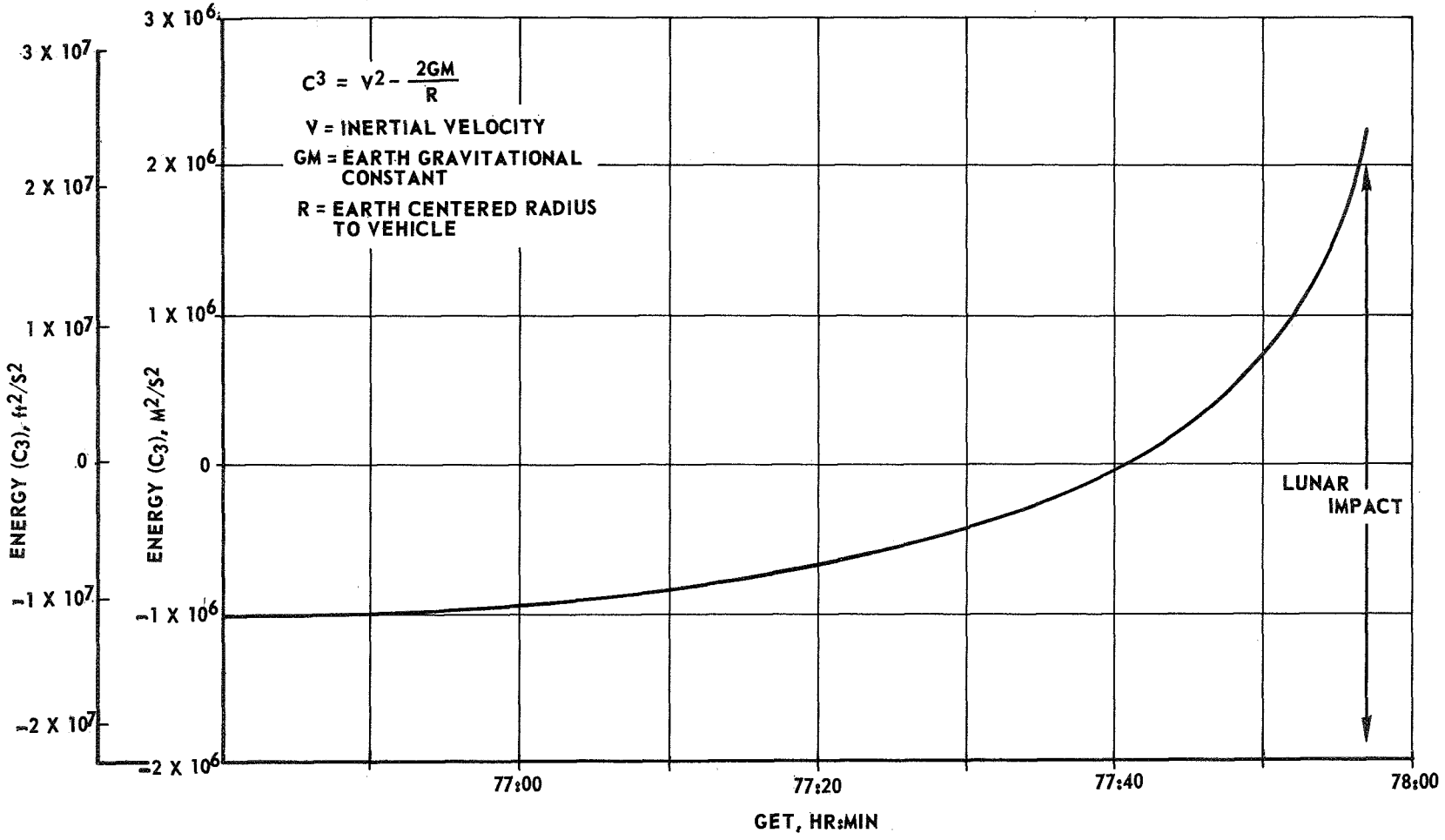


FIGURE 3.11 EARTH REFERENCED C_3 NEAR-MOON

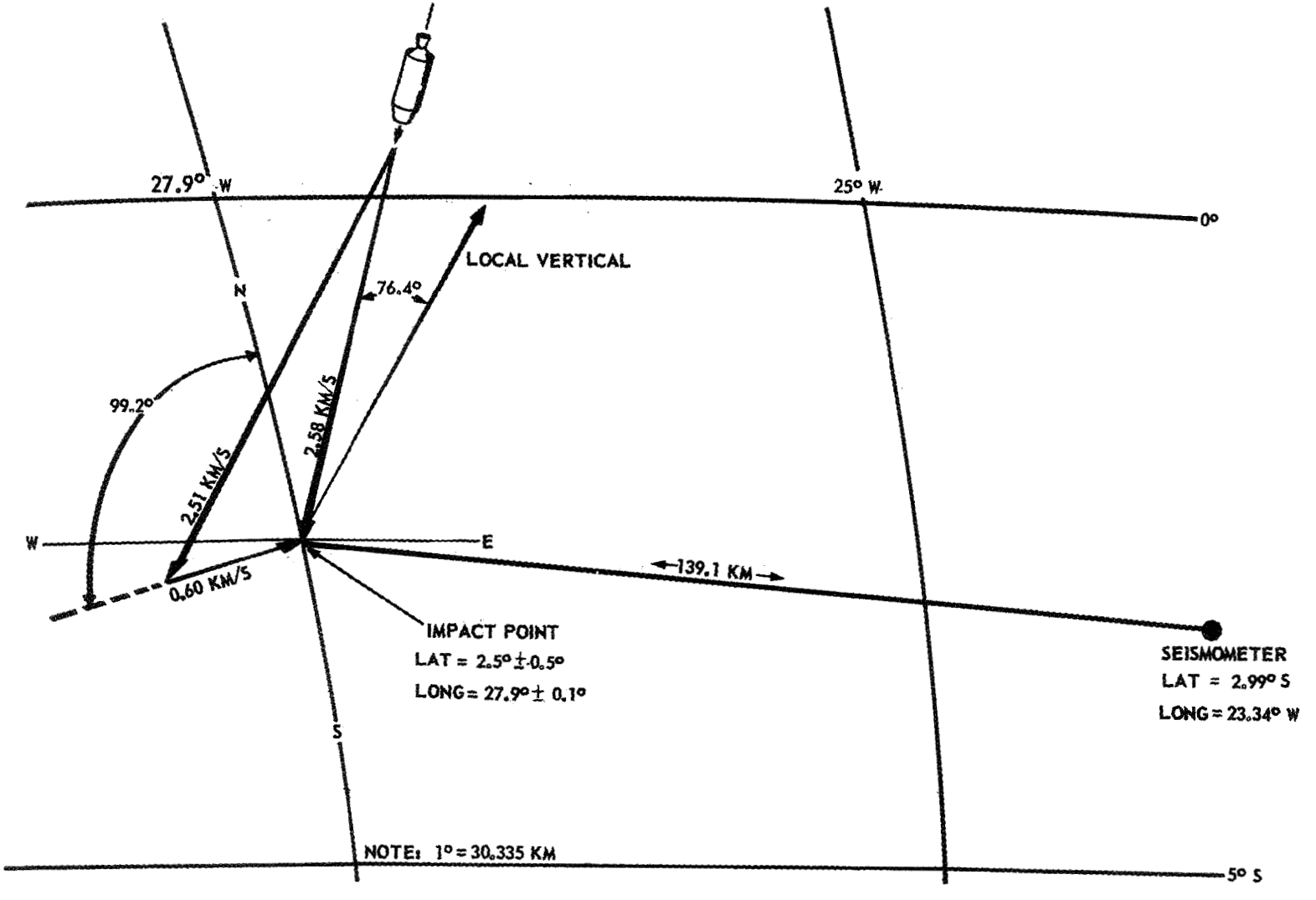


FIGURE 3.12 S-IVB/IU LUNAR IMPACT CONDITIONS

3.2 Time History of Trajectory Parameters

Definitions of the trajectory parameters presented in this subsection are given in the appendix. The Greenwich Mean Times (G.M.T. = HOURS, MINUTES, SECONDS, MONTH, DAY) which correspond to significant trajectory events are preceded by the event identification.

CSM SEPARATION FROM LM/S-IVB/IU

G.M.T.=22:19:38.900 APRIL 11

R=	1.33727507E 04 KM	VEL=	7.62820056E 00 KM/S
DECL=	2.68999800E 01 DEG	EL=	4.50600082E 01 DEG
LONG=	-1.29644617E 02 DEG	AZ=	7.23457514E 01 DEG
X=	8.43577307E 03 KM	DX=	-7.46191431E-01 KM/S
Y=	8.42983718E 03 KM	DY=	6.51310475E 00 KM/S
Z=	6.05029240E 03 KM	DZ=	3.90027032E 00 KM/S
XM=	2.33377549E 04 KM	DXM=	2.38242123E-01 KM/S
YM=	-3.41362541E 05 KM	DYM=	6.49544116E 00 KM/S
ZM=	-1.92058196E 05 KM	DZM=	3.92361243E 00 KM/S

G.M.T.=22:20:00.000 APRIL 11

R=	1.34866669E 04 KM	VEL=	7.59512032E 00 KM/S
DECL=	2.70455169E 01 DEG	EL=	4.52949872E 01 DEG
LONG=	-1.29215997E 02 DEG	AZ=	7.25809698E 01 DEG
X=	8.41971679E 03 KM	DX=	-7.75526900E-01 KM/S
Y=	8.36695256E 03 KM	DY=	6.48362942E 00 KM/S
Z=	6.13236301E 03 KM	DZ=	3.87904116E 00 KM/S
XM=	2.33424701E 04 KM	DXM=	2.08904048E-01 KM/S
YM=	-3.41225798E 05 KM	DYM=	6.46601341E 00 KM/S
ZM=	-1.91975633E 05 KM	DZM=	3.90240888E 00 KM/S

G.M.T.=22:25:00.000 APRIL 11

R=	1.50997676E 04 KM	VEL=	7.16728308E 00 KM/S
DECL=	2.97103693E 01 DEG	EL=	4.82557453E 01 DEG
LONG=	-1.23851786E 02 DEG	AZ=	7.56800461E 01 DEG
X=	8.13262054E 03 KM	DX=	-1.11720242E 00 KM/S
Y=	1.04521711E 04 KM	DY=	6.09361254E 00 KM/S
Z=	7.25366010E 03 KM	DZ=	3.60412148E 00 KM/S
XM=	2.33506978E 04 KM	DXM=	-1.32808836E-01 KM/S
YM=	-3.39345763E 05 KM	DYM=	6.07667314E 00 KM/S
ZM=	-1.90847271E 05 KM	DZM=	3.62785320E 00 KM/S

G.M.T.=22:30:00.000 APRIL 11

R=	1.66919099E 04 KM	VEL=	6.80686945E 00 KM/S
DECL=	2.98145318E 01 DEG	EL=	5.06402846E 01 DEG
LONG=	-1.19617264E 02 DEG	AZ=	7.83656063E 01 DEG
X=	7.75967574E 03 KM	DX=	-1.35531772E 00 KM/S
Y=	1.22283249E 04 KM	DY=	5.75551989E 00 KM/S
Z=	8.29911803E 03 KM	DZ=	3.37202854E 00 KM/S
XM=	2.52730654E 04 KM	DXM=	-3.70962058E-01 KM/S
YM=	-3.37574589E 05 KM	DYM=	5.73925702E 00 KM/S
ZM=	-1.79794639E 05 KM	DZM=	3.39612422E 00 KM/S

G.M.T.=22:35:00.000 APRIL 11

R=	1.92560986E 04 KM	VEL=	6.49931213E 00 KM/S
DECL=	3.05534561E 01 DEG	EL=	5.26063991E 01 DEG
LONG=	-1.16248079E 02 DEG	AZ=	8.06917565E 01 DEG
X=	7.32620152E 03 KM	DX=	-1.52528229E 00 KM/S
Y=	1.39099661E 04 KM	DY=	5.46225932E 00 KM/S
Z=	9.28034221E 03 KM	DZ=	3.17463308E 00 KM/S
XM=	2.51348921E 04 KM	DXM=	-5.40965113E-01 KM/S
YM=	-3.35897725E 05 KM	DYM=	5.44667294E 00 KM/S
ZM=	-1.78806131E 05 KM	DZM=	3.19909266E 00 KM/S

G.M.T.=22:40:00.000 APRIL 11

R=	1.97896137E 04 KM	VEL=	6.23353900E 00 KM/S
DECL=	3.10482252E 01 DEG	EL=	5.42596758E 01 DEG
LONG=	-1.13553005E 02 DEG	AZ=	8.27150135E 01 DEG
X=	6.94910862E 03 KM	DX=	-1.64896928E 00 KM/S
Y=	1.55094241E 04 KM	DY=	5.20646985E 00 KM/S
Z=	1.02066785E 04 KM	DZ=	3.00509243E 00 KM/S
XM=	2.49530888E 04 KM	DXM=	-6.64691149E-01 KM/S
YM=	-3.34302842E 05 KM	DYM=	5.19155988E 00 KM/S
ZM=	-1.77872402E 05 KM	DZM=	3.02991587E 00 KM/S

G.M.T.=22:45:00.000 APRIL 11

R=	2.12919024E 04 KM	VEL=	6.00121528E 00 KM/S
DECL=	3.13758901E 01 DEG	EL=	5.56729531E 01 DEG
LONG=	-1.11391692E 02 DEG	AZ=	8.44855856E 01 DEG
X=	6.34003766E 03 KM	DX=	-1.74032501E 00 KM/S
Y=	1.70369500E 04 KM	DY=	4.98173929E 00 KM/S
Z=	1.10856378E 04 KM	DZ=	2.85799358E 00 KM/S
XM=	2.47392953E 04 KM	DXM=	-7.56086490E-01 KM/S
YM=	-3.32779687E 05 KM	DYM=	4.96750569E 00 KM/S
ZM=	-1.76985941E 05 KM	DZM=	2.88318083E 00 KM/S

G.M.T.=22:50:00.000 APRIL 11

R=	2.27635091E 04 KM	VEL=	5.79603297E 00 KM/S
DECL=	3.15868124E 01 DEG	EL=	5.68979400E 01 DEG
LONG=	-1.09659490E 02 DEG	AZ=	8.60455260E 01 DEG
X=	5.30721998E 03 KM	DX=	-1.80852092E 00 KM/S
Y=	1.95010426E 04 KM	DY=	4.78279205E 00 KM/S
Z=	1.19232950E 04 KM	DZ=	2.72912998E 00 KM/S
XM=	2.45017432E 04 KM	DXM=	-8.24322561E-01 KM/S
YM=	-3.31319763E 05 KM	DYM=	4.76923476E 00 KM/S
ZM=	-1.76140673E 05 KM	DZM=	2.75468098E 00 KM/S

G.M.T.=22:55:00.000 APRIL 11

R=	2.42055165E 04 KM	VEL=	5.61316481E 00 KM/S
DECL=	3.17147398E 01 DEG	EL=	5.79723091E 01 DEG
LONG=	-1.08277119E 02 DEG	AZ=	8.74292470E 01 DEG
X=	5.25661439E 03 KM	DX=	-1.85976228E 00 KM/S
Y=	1.99087751E 04 KM	DY=	4.60537142E 00 KM/S
Z=	1.27246104E 04 KM	DZ=	2.61523565E 00 KM/S
XM=	2.42463913E 04 KM	DXM=	-8.75604650E-01 KM/S
YM=	-3.29915997E 05 KM	DYM=	4.59249037E 00 KM/S
ZM=	-1.75331638E 05 KM	DZM=	2.64115034E 00 KM/S

G.M.T.=23:00:00.000 APRIL 11

R=	2.56192489E 04 KM	VEL=	5.44886830E 00 KM/S
DECL=	3.17828045E 01 DEG	EL=	5.89241471E 01 DEG
LONG=	-1.07183602E 02 DEG	AZ=	8.86646887E 01 DEG
X=	4.59262329E 03 KM	DX=	-1.89835611E 00 KM/S
Y=	2.12660739E 04 KM	DY=	4.44605717E 00 KM/S
Z=	1.34936764E 04 KM	DZ=	2.51375922E 00 KM/S
XM=	2.39776413E 04 KM	DXM=	-9.14239759E-01 KM/S
YM=	-3.28562461E 05 KM	DYM=	4.43385231E 00 KM/S
ZM=	-1.74554743E 05 KM	DZM=	2.54003757E 00 KM/S

G.M.T.=23:05:00.000 APRIL 11

R=	2.70061117E 04 KM	VEL=	5.30020320E 00 KM/S
DECL=	3.18071850E 01 DEG	EL=	5.97748264E 01 DEG
LONG=	-1.06331356E 02 DEG	AZ=	8.97745289E 01 DEG
X=	4.11855691E 03 KM	DX=	-1.92736051E 00 KM/S
Y=	2.25779428E 04 KM	DY=	4.30209384E 00 KM/S
Z=	1.42339052E 04 KM	DZ=	2.42268941E 00 KM/S
XM=	2.36988036E 04 KM	DXM=	-9.43286011E-01 KM/S
YM=	-3.27254152E 05 KM	DYM=	4.29056510E 00 KM/S
ZM=	-1.73806576E 05 KM	DZM=	2.44933136E 00 KM/S

G.M.T.=23:10:00.000 APRIL 11

R=	2.83675059E 04 KM	VEL=	5.16482975E 00 KM/S
DECL=	3.17994008E 01 DEG	EL=	6.05409074E 01 DEG
LONG=	-1.05682758E 02 DEG	AZ=	9.07772383E 01 DEG
X=	3.53694246E 03 KM	DX=	-1.94899110E 00 KM/S
Y=	2.38486406E 04 KM	DY=	4.17124842E 00 KM/S
Z=	1.49481695E 04 KM	DZ=	2.34042445E 00 KM/S
XM=	2.34124053E 04 KM	DXM=	-9.64958999E-01 KM/S
YM=	-3.25986811E 05 KM	DYM=	4.16039575E 00 KM/S
ZM=	-1.73084265E 05 KM	DZM=	2.36742994E 00 KM/S

CSM/LM EJECTION FROM S-IVB/IU

G.M.T.=23:14:00.800 APRIL 11

R=	2.94427421E 04 KM	VEL=	5.06450006E 00 KM/S
DECL=	3.17755946E 01 DEG	EL=	6.11035170E 01 DEG
LONG=	-1.05288921E 02 DEG	AZ=	9.15148901E 01 DEG
X=	3.06597553E 03 KM	DX=	-1.96213772E 00 KM/S
Y=	2.48412876E 04 KM	DY=	4.07447021E 00 KM/S
Z=	1.55043634E 04 KM	DZ=	2.27988354E 00 KM/S
XM=	2.31783892E 04 KM	DXM=	-9.78140058E-01 KM/S
YM=	-3.24996712E 05 KM	DYM=	4.06416015E 00 KM/S
ZM=	-1.72521533E 05 KM	DZM=	2.30718079E 00 KM/S

G.M.T.=23:15:00.000 APRIL 11

R=	2.97047825E 04 KM	VEL=	5.04091845E 00 KM/S
DECL=	3.17677697E 01 DEG	EL=	6.12338216E 01 DEG
LONG=	-1.05207665E 02 DEG	AZ=	9.16909623E 01 DEG
X=	2.94972649E 03 KM	DX=	-1.96502285E 00 KM/S
Y=	2.50818245E 04 KM	DY=	4.05176751E 00 KM/S
Z=	1.56389034E 04 KM	DZ=	2.26555162E 00 KM/S
XM=	2.31203926E 04 KM	DXM=	-9.81033712E-01 KM/S
YM=	-3.24756782E 05 KM	DYM=	4.04159084E 00 KM/S
ZM=	-1.72385375E 05 KM	DZM=	2.29292060E 00 KM/S

G.M.T.=23:20:00.000 APRIL 11

R=	3.10192197E 04 KM	VEL=	4.92682607E 00 KM/S
DECL=	3.17183598E 01 DEG	EL=	6.18672559E 01 DEG
LONG=	-1.04881633E 02 DEG	AZ=	9.25221738E 01 DEG
X=	2.35841316E 03 KM	DX=	-1.97639868E 00 KM/S
Y=	2.52806632E 04 KM	DY=	3.94201247E 00 KM/S
Z=	1.63081766E 04 KM	DZ=	2.19727127E 00 KM/S
XM=	2.28242695E 04 KM	DXM=	-9.92453068E-01 KM/S
YM=	-3.23560894E 05 KM	DYM=	3.93251175E 00 KM/S
ZM=	-1.71707836E 05 KM	DZM=	2.22500369E 00 KM/S

G.M.T.=23:25:00.000 APRIL 11

R= 3.23120243E 04 KM	VEL= 4.82134252E 00 KM/S
DECL= 3.16557724E 01 DEG	EL= 6.24479691E 01 DEG
LONG=-1.04684792E 02 DEG	AZ= 9.32841788E 01 DEG
X= 1.76424500E 03 KM	DX=-1.98419031E 00 KM/S
Y= 2.74478864E 04 KM	DY= 3.84080919E 00 KM/S
Z= 1.69578266E 04 KM	DZ= 2.13460002E 00 KM/S
XM= 2.25252787E 04 KM	DXM=-1.00028878E 00 KM/S
YM=-3.22396420E 05 KM	DYM= 3.83198435E 00 KM/S
ZM=-1.71049812E 05 KM	DZM= 2.16269583E 00 KM/S

G.M.T.=23:30:00.000 APRIL 11

R= 3.35843149E 04 KM	VEL= 4.72341843E 00 KM/S
DECL= 3.15834131E 01 DEG	EL= 6.29828596E 01 DEG
LONG=-1.04600655E 02 DEG	AZ= 9.39856156E 01 DEG
X= 1.16818519E 03 KM	DX=-1.98911446E 00 KM/S
Y= 2.95858994E 04 KM	DY= 3.74711864E 00 KM/S
Z= 1.75894260E 04 KM	DZ= 2.07682623E 00 KM/S
XM= 2.22243827E 04 KM	DXM=-1.00525757E 00 KM/S
YM=-3.21260953E 05 KM	DYM= 3.73896962E 00 KM/S
ZM=-1.70409729E 05 KM	DZM= 2.10528538E 00 KM/S

EVASIVE BURN, APS ENGINES ON

G.M.T.=23:31:00.600 APRIL 11

R= 3.38389211E 04 KM	VEL= 4.70447452E 00 KM/S
DECL= 3.15678520E 01 DEG	EL= 6.30858709E 01 DEG
LONG=-1.04596075E 02 DEG	AZ= 9.41206212E 01 DEG
X= 1.04762325E 03 KM	DX=-1.98981307E 00 KM/S
Y= 2.88124252E 04 KM	DY= 3.72902474E 00 KM/S
Z= 1.77149435E 04 KM	DZ= 2.06369574E 00 KM/S
XM= 2.21634421E 04 KM	DXM=-1.00596527E 00 KM/S
YM=-3.21034917E 05 KM	DYM= 3.72101223E 00 KM/S
ZM=-1.70282485E 05 KM	DZM= 2.09422828E 00 KM/S

EVASIVE BURN, APS ENGINES OFF

G.M.T.=23:32:20.800 APRIL 11

R= 3.41746754E 04 KM	VEL= 4.67892097E 00 KM/S
DECL= 3.15466939E 01 DEG	EL= 6.32453041E 01 DEG
LONG=-1.04596278E 02 DEG	AZ= 9.43476849E 01 DEG
X= 8.88130255E 02 KM	DX=-1.98815410E 00 KM/S
Y= 2.91105942E 04 KM	DY= 3.70644861E 00 KM/S
Z= 1.78799598E 04 KM	DZ= 2.04982522E 00 KM/S
XM= 2.20828532E 04 KM	DXM=-1.00431836E 00 KM/S
YM=-3.20737383E 05 KM	DYM= 3.69861675E 00 KM/S
ZM=-1.70115177E 05 KM	DZM= 2.07845487E 00 KM/S

G.M.T.=23:33:00.000 APRIL 11

R=	3.43382911E 04 KM	VEL=	4.66702811E 00 KM/S
DECL=	3.15361487E 01 DEG	EL=	6.33096619E 01 DEG
LONG=	-1.04598881E 02 DEG	AZ=	9.44320181E 01 DEG
X=	8.10187997E 02 KM	DX=	-1.98848416E 00 KM/S
Y=	2.92556644E 04 KM	DY=	3.69510592E 00 KM/S
Z=	1.79601763E 04 KM	DZ=	2.04285935E 00 KM/S
XM=	2.20434774E 04 KM	DXM=	-1.00465432E 00 KM/S
YM=	-3.20592618E 05 KM	DYM=	3.68736236E 00 KM/S
ZM=	-1.70033837E 05 KM	DZM=	2.07153648E 00 KM/S

G.M.T.=23:34:00.000 APRIL 11

R=	3.45880988E 04 KM	VEL=	4.64902962E 00 KM/S
DECL=	3.15198171E 01 DEG	EL=	6.34069471E 01 DEG
LONG=	-1.04605885E 02 DEG	AZ=	9.45594710E 01 DEG
X=	6.90865393E 02 KM	DX=	-1.98892276E 00 KM/S
Y=	2.94768548E 04 KM	DY=	3.67794810E 00 KM/S
Z=	1.80824311E 04 KM	DZ=	2.03232882E 00 KM/S
XM=	2.19831843E 04 KM	DXM=	-1.00510198E 00 KM/S
YM=	-3.20371889E 05 KM	DYM=	3.67033968E 00 KM/S
ZM=	-1.69909859E 05 KM	DZM=	2.06107859E 00 KM/S

G.M.T.=23:35:00.000 APRIL 11

R=	3.48371579E 04 KM	VEL=	4.63127389E 00 KM/S
DECL=	3.15032674E 01 DEG	EL=	6.35027869E 01 DEG
LONG=	-1.04616463E 02 DEG	AZ=	9.46849956E 01 DEG
X=	5.71518818E 02 KM	DX=	-1.98928374E 00 KM/S
Y=	2.96970230E 04 KM	DY=	3.66103132E 00 KM/S
Z=	1.82040588E 04 KM	DZ=	2.02195395E 00 KM/S
XM=	2.19228666E 04 KM	DXM=	-1.00547205E 00 KM/S
YM=	-3.20152173E 05 KM	DYM=	3.65355805E 00 KM/S
ZM=	-1.69786504E 05 KM	DZM=	2.05077638E 00 KM/S

G.M.T.=23:36:00.000 APRIL 11

R=	3.50854757E 04 KM	VEL=	4.61375539E 00 KM/S
DECL=	3.14865136E 01 DEG	EL=	6.35972165E 01 DEG
LONG=	-1.04630529E 02 DEG	AZ=	9.48086380E 01 DEG
X=	4.52152833E 02 KM	DX=	-1.98957026E 00 KM/S
Y=	2.99161833E 04 KM	DY=	3.64435005E 00 KM/S
Z=	1.83250686E 04 KM	DZ=	2.01173102E 00 KM/S
XM=	2.18625293E 04 KM	DXM=	-1.00576768E 00 KM/S
YM=	-3.19933457E 05 KM	DYM=	3.63701193E 00 KM/S
ZM=	-1.69663763E 05 KM	DZM=	2.04062610E 00 KM/S

G.M.T.=23:37:00.000 APRIL 11

R=	3.53330597E 04 KM	VEL=	4.59646873E 00 KM/S
DECL=	3.14695688E 01 DEG	EL=	6.36902700E 01 DEG
LONG=	-1.04647999E 02 DEG	AZ=	9.49304424E 01 DEG
X=	3.32771815E 02 KM	DX=	-1.98978536E 00 KM/S
Y=	3.01343496E 04 KM	DY=	3.62789892E 00 KM/S
Z=	1.94454695E 04 KM	DZ=	2.00165642E 00 KM/S
XM=	2.18021761E 04 KM	DXM=	-1.00599191E 00 KM/S
YM=	-3.19715727E 05 KM	DYM=	3.62069594E 00 KM/S
ZM=	-1.69541626E 05 KM	DZM=	2.03062415E 00 KM/S

G.M.T.=23:38:00.000 APRIL 11

R=	3.55799172E 04 KM	VEL=	4.57940871E 00 KM/S
DECL=	3.14524457E 01 DEG	EL=	6.37819806E 01 DEG
LONG=	-1.04668795E 02 DEG	AZ=	9.50504521E 01 DEG
X=	2.13379960E 02 KM	DX=	-1.98993194E 00 KM/S
Y=	3.03515357E 04 KM	DY=	3.61167272E 00 KM/S
Z=	1.95652703E 04 KM	DZ=	1.99172667E 00 KM/S
XM=	2.17418115E 04 KM	DXM=	-1.00614764E 00 KM/S
YM=	-3.19498969E 05 KM	DYM=	3.60460488E 00 KM/S
ZM=	-1.69420085E 05 KM	DZM=	2.02076704E 00 KM/S

G.M.T.=23:39:00.000 APRIL 11

R=	3.58260553E 04 KM	VEL=	4.56257028E 00 KM/S
DECL=	3.14351561E 01 DEG	EL=	6.38723801E 01 DEG
LONG=	-1.04692837E 02 DEG	AZ=	9.51687086E 01 DEG
X=	9.39812969E 01 KM	DX=	-1.99001276E 00 KM/S
Y=	3.05677547E 04 KM	DY=	3.59566642E 00 KM/S
Z=	1.96844796E 04 KM	DZ=	1.98193838E 00 KM/S
XM=	2.16814396E 04 KM	DXM=	-1.00623763E 00 KM/S
YM=	-3.19283170E 05 KM	DYM=	3.58873372E 00 KM/S
ZM=	-1.69299131E 05 KM	DZM=	2.01105139E 00 KM/S

G.M.T.=23:40:00.000 APRIL 11

R=	3.60714810E 04 KM	VEL=	4.54594855E 00 KM/S
DECL=	3.14177114E 01 DEG	EL=	6.39614993E 01 DEG
LONG=	-1.04720050E 02 DEG	AZ=	9.52852524E 01 DEG
X=	-2.54203087E 01 KM	DX=	-1.99003046E 00 KM/S
Y=	3.07830199E 04 KM	DY=	3.57987514E 00 KM/S
Z=	1.98031057E 04 KM	DZ=	1.97228827E 00 KM/S
XM=	2.16210644E 04 KM	DXM=	-1.00626452E 00 KM/S
YM=	-3.19068316E 05 KM	DYM=	3.57307756E 00 KM/S
ZM=	-1.69178756E 05 KM	DZM=	2.00147393E 00 KM/S

G.M.T.=23:41:00.000 APRIL 11

R=	3.53162014E 04 KM	VEL=	4.52953879E 00 KM/S
DECL=	3.14001223E 01 DEG	EL=	6.40493682E 01 DEG
LONG=	-1.04750362E 02 DEG	AZ=	9.54001227E 01 DEG
X=	-1.44821146E 02 KM	DX=	-1.98998757E 00 KM/S
Y=	3.09973440E 04 KM	DY=	3.56429411E 00 KM/S
Z=	1.89211569E 04 KM	DZ=	1.96277319E 00 KM/S
XM=	2.15606892E 04 KM	DXM=	-1.00623085E 00 KM/S
YM=	-3.18854396E 05 KM	DYM=	3.55763167E 00 KM/S
ZM=	-1.69058952E 05 KM	DZM=	1.99203149E 00 KM/S

G.M.T.=23:42:00.000 APRIL 11

R=	3.55602231E 04 KM	VEL=	4.51333640E 00 KM/S
DECL=	3.13823989E 01 DEG	EL=	6.41360155E 01 DEG
LONG=	-1.04783702E 02 DEG	AZ=	9.55133575E 01 DEG
X=	-2.54217654E 02 KM	DX=	-1.98988651E 00 KM/S
Y=	3.12107393E 04 KM	DY=	3.54891877E 00 KM/S
Z=	1.90386411E 04 KM	DZ=	1.95339006E 00 KM/S
XM=	2.15003178E 04 KM	DXM=	-1.00613904E 00 KM/S
YM=	-3.18641397E 05 KM	DYM=	3.54239145E 00 KM/S
ZM=	-1.68939710E 05 KM	DZM=	1.98272099E 00 KM/S

G.M.T.=23:43:00.000 APRIL 11

R=	3.58035530E 04 KM	VEL=	4.49733692E 00 KM/S
DECL=	3.13645510E 01 DEG	EL=	6.42214694E 01 DEG
LONG=	-1.04820001E 02 DEG	AZ=	9.56249936E 01 DEG
X=	-3.83606411E 02 KM	DX=	-1.98972960E 00 KM/S
Y=	3.14232182E 04 KM	DY=	3.53374463E 00 KM/S
Z=	1.91555662E 04 KM	DZ=	1.94413590E 00 KM/S
XM=	2.14399536E 04 KM	DXM=	-1.00599139E 00 KM/S
YM=	-3.18429305E 05 KM	DYM=	3.52735244E 00 KM/S
ZM=	-1.68821023E 05 KM	DZM=	1.97353947E 00 KM/S

G.M.T.=23:44:00.000 APRIL 11

R=	3.70461977E 04 KM	VEL=	4.48153603E 00 KM/S
DECL=	3.13465878E 01 DEG	EL=	6.43057567E 01 DEG
LONG=	-1.04859193E 02 DEG	AZ=	9.57350668E 01 DEG
X=	-5.02984133E 02 KM	DX=	-1.98951905E 00 KM/S
Y=	3.16347926E 04 KM	DY=	3.51876737E 00 KM/S
Z=	1.92719399E 04 KM	DZ=	1.93500783E 00 KM/S
XM=	2.13796000E 04 KM	DXM=	-1.00579013E 00 KM/S
YM=	-3.18218110E 05 KM	DYM=	3.51251031E 00 KM/S
ZM=	-1.68702883E 05 KM	DZM=	1.96448404E 00 KM/S

G.M.T.=23:45:00.000 APRIL 11

R=	3.72881637E 04 KM	VEL=	4.46592953E 00 KM/S
DECL=	3.13285180E 01 DEG	EL=	6.43889039E 01 DEG
LONG=	-1.04901213E 02 DEG	AZ=	9.58436116E 01 DEG
X=	-6.22347667E 02 KM	DX=	-1.98925699E 00 KM/S
Y=	3.18454742E 04 KM	DY=	3.50398279E 00 KM/S
Z=	1.93877696E 04 KM	DZ=	1.92600306E 00 KM/S
XM=	2.13192599E 04 KM	DXM=	-1.00553737E 00 KM/S
YM=	-3.18007800E 05 KM	DYM=	3.49786085E 00 KM/S
ZM=	-1.68585282E 05 KM	DZM=	1.95555189E 00 KM/S

G.M.T.=23:47:00.000 APRIL 11

R=	3.77700852E 04 KM	VEL=	4.43528354E 00 KM/S
DECL=	3.12920914E 01 DEG	EL=	6.45518786E 01 DEG
LONG=	-1.04993492E 02 DEG	AZ=	9.60562498E 01 DEG
X=	-8.51020148E 02 KM	DX=	-1.98858636E 00 KM/S
Y=	3.22642042E 04 KM	DY=	3.47497549E 00 KM/S
Z=	1.96178262E 04 KM	DZ=	1.90835262E 00 KM/S
XM=	2.11986326E 04 KM	DXM=	-1.00488542E 00 KM/S
YM=	-3.17589788E 05 KM	DYM=	3.46912378E 00 KM/S
ZM=	-1.68351671E 05 KM	DZM=	1.93804671E 00 KM/S

CONTINUOUS VENT SYSTEM ON

G.M.T.=23:47:39.400 APRIL 11

R=	3.79277384E 04 KM	VEL=	4.42538213E 00 KM/S
DECL=	3.12800561E 01 DEG	EL=	6.46044492E 01 DEG
LONG=	-1.05026122E 02 DEG	AZ=	9.61248061E 01 DEG
X=	-9.39365417E 02 KM	DX=	-1.98832560E 00 KM/S
Y=	3.24009336E 04 KM	DY=	3.46561061E 00 KM/S
Z=	1.96929031E 04 KM	DZ=	1.90265904E 00 KM/S
XM=	2.11590452E 04 KM	DXM=	-1.00463082E 00 KM/S
YM=	-3.17453288E 05 KM	DYM=	3.45984763E 00 KM/S
ZM=	-1.68275423E 05 KM	DZM=	1.93240082E 00 KM/S

LOX DUMP INITIATION

G.M.T.=23:52:19.400 APRIL 11

R=	3.90400635E 04 KM	VEL=	4.35698254E 00 KM/S
DECL=	3.11937029E 01 DEG	EL=	6.49702324E 01 DEG
LONG=	-1.05289719E 02 DEG	AZ=	9.65937206E 01 DEG
X=	-1.49566321E 03 KM	DX=	-1.98551539E 00 KM/S
Y=	3.33621883E 04 KM	DY=	3.40116226E 00 KM/S
Z=	2.02201372E 04 KM	DZ=	1.86363108E 00 KM/S
XM=	2.08781758E 04 KM	DXM=	-1.00186462E 00 KM/S
YM=	-3.16493558E 05 KM	DYM=	3.39602978E 00 KM/S
ZM=	-1.67739814E 05 KM	DZM=	1.89371176E 00 KM/S

LOX DUMP TERMINATION

G.M.T.=23:53:07.400 APRIL 11

R=	3.92293438E 04 KM	VEL=	4.34157750E 00 KM/S
DECL=	3.11788537E 01 DEG	EL=	6.51308535E 01 DEG
LONG=	-1.05340653E 02 DEG	AZ=	9.66474477E 01 DEG
X=	-1.59069853E 03 KM	DX=	-1.97643284E 00 KM/S
Y=	3.35251602E 04 KM	DY=	3.38958001E 00 KM/S
Z=	2.03094739E 04 KM	DZ=	1.85842831E 00 KM/S
XM=	2.08303557E 04 KM	DXM=	-9.92789663E-01 KM/S
YM=	-3.16330830E 05 KM	DYM=	3.38455561E 00 KM/S
ZM=	-1.57649032E 05 KM	DZM=	1.88856707E 00 KM/S

G.M.T.=23:55:00.000 APRIL 11

R=	3.96717766E 04 KM	VEL=	4.31539853E 00 KM/S
DECL=	3.11440233E 01 DEG	EL=	6.52676485E 01 DEG
LONG=	-1.05466515E 02 DEG	AZ=	9.68257927E 01 DEG
X=	-1.81317597E 03 KM	DX=	-1.97518901E 00 KM/S
Y=	3.39054342E 04 KM	DY=	3.36493439E 00 KM/S
Z=	2.05178894E 04 KM	DZ=	1.84350467E 00 KM/S
XM=	2.07186355E 04 KM	DXM=	-9.91563699E-01 KM/S
YM=	-3.15951108E 05 KM	DYM=	3.36016352E 00 KM/S
ZM=	-1.57437215E 05 KM	DZM=	1.87377970E 00 KM/S

G.M.T.=00:00:00.000 APRIL 12

R=	4.08400577E 04 KM	VEL=	4.24827377E 00 KM/S
DECL=	3.10507189E 01 DEG	EL=	6.56170640E 01 DEG
LONG=	-1.05839288E 02 DEG	AZ=	9.72807422E 01 DEG
X=	-2.40517240E 03 KM	DX=	-1.97132897E 00 KM/S
Y=	3.49053619E 04 KM	DY=	3.30186011E 00 KM/S
Z=	2.10651649E 04 KM	DZ=	1.80538415E 00 KM/S
XM=	2.04217195E 04 KM	DXM=	-9.87751653E-01 KM/S
YM=	-3.14952510E 05 KM	DYM=	3.29776468E 00 KM/S
ZM=	-1.56880803E 05 KM	DZM=	1.83602219E 00 KM/S

G.M.T.=00:05:00.000 APRIL 12

R=	4.19936052E 04 KM	VEL=	4.18468970E 00 KM/S
DECL=	3.09570878E 01 DEG	EL=	6.59462634E 01 DEG
LONG=	-1.06262382E 02 DEG	AZ=	9.77085327E 01 DEG
X=	-2.99590540E 03 KM	DX=	-1.96678856E 00 KM/S
Y=	3.58868991E 04 KM	DY=	3.24227552E 00 KM/S
Z=	2.16013403E 04 KM	DZ=	1.76946886E 00 KM/S
XM=	2.01260522E 04 KM	DXM=	-9.83259796E-01 KM/S
YM=	-3.13972100E 05 KM	DYM=	3.23885547E 00 KM/S
ZM=	-1.56335381E 05 KM	DZM=	1.80046987E 00 KM/S

G.M.T.=00:10:00.000 APRIL 12

R=	4.31330415E 04 KM	VEL=	4.12433538E 00 KM/S
DECL=	3.08635499E 01 DEG	EL=	6.62571197E 01 DEG
LONG=	-1.06731155E 02 DEG	AZ=	9.81116889E 01 DEG
X=	-3.58518977E 03 KM	DX=	-1.96168981E 00 KM/S
Y=	3.68510449E 04 KM	DY=	3.18586923E 00 KM/S
Z=	2.21270463E 04 KM	DZ=	1.73555542E 00 KM/S
XM=	1.98318192E 04 KM	DXM=	-9.78210152E-01 KM/S
YM=	-3.13008879E 05 KM	DYM=	3.18312450E 00 KM/S
ZM=	-1.65800321E 05 KM	DZM=	1.76691934E 00 KM/S

G.M.T.=00:15:00.000 APRIL 12

R=	4.42589465E 04 KM	VEL=	4.06693698E 00 KM/S
DECL=	3.07704320E 01 DEG	EL=	6.65512717E 01 DEG
LONG=	-1.07241534E 02 DEG	AZ=	9.84924265E 01 DEG
X=	-4.17287359E 03 KM	DX=	-1.95613351E 00 KM/S
Y=	3.77987109E 04 KM	DY=	3.13236707E 00 KM/S
Z=	2.26428559E 04 KM	DZ=	1.70346548E 00 KM/S
XM=	1.95391717E 04 KM	DXM=	-9.72703511E-01 KM/S
YM=	-3.12061935E 05 KM	DYM=	3.13029757E 00 KM/S
ZM=	-1.65275047E 05 KM	DZM=	1.73519225E 00 KM/S

G.M.T.=00:20:00.000 APRIL 12

R=	4.53718608E 04 KM	VEL=	4.01225227E 00 KM/S
DECL=	3.06779877E 01 DEG	EL=	6.68301605E 01 DEG
LONG=	-1.07789938E 02 DEG	AZ=	9.88526985E 01 DEG
X=	-4.75883254E 03 KM	DX=	-1.95020330E 00 KM/S
Y=	3.87307312E 04 KM	DY=	3.08152659E 00 KM/S
Z=	2.31492921E 04 KM	DZ=	1.67304191E 00 KM/S
XM=	1.92482341E 04 KM	DXM=	-9.66823518E-01 KM/S
YM=	-3.11130435E 05 KM	DYM=	3.08013228E 00 KM/S
ZM=	-1.64759039E 05 KM	DZM=	1.70513148E 00 KM/S

G.M.T.=00:25:00.000 APRIL 12

R=	4.64722899E 04 KM	VEL=	3.96006610E 00 KM/S
DECL=	3.05864127E 01 DEG	EL=	6.70950585E 01 DEG
LONG=	-1.08373197E 02 DEG	AZ=	9.91942328E 01 DEG
X=	-5.34296519E 03 KM	DX=	-1.94396887E 00 KM/S
Y=	3.96478714E 04 KM	DY=	3.03313260E 00 KM/S
Z=	2.36468337E 04 KM	DZ=	1.64414575E 00 KM/S
XM=	1.89591078E 04 KM	DXM=	-9.60639870E-01 KM/S
YM=	-3.10213611E 05 KM	DYM=	3.03241340E 00 KM/S
ZM=	-1.64251816E 05 KM	DZM=	1.67659806E 00 KM/S

G.M.T.=00:30:00.000 APRIL 12

R=	4.75607066E 04 KM	VEL=	3.91018665E 00 KM/S
DECL=	3.04958570E 01 DEG	EL=	6.73470945E 01 DEG
LONG=	-1.08988497E 02 DEG	AZ=	9.95185641E 01 DEG
X=	-5.92518930E 03 KM	DX=	-1.93748853E 00 KM/S
Y=	4.05508362E 04 KM	DY=	2.98699333E 00 KM/S
Z=	2.41359199E 04 KM	DZ=	1.61665355E 00 KM/S
XM=	1.86718746E 04 KM	DXM=	-9.54210862E-01 KM/S
YM=	-3.09310761E 05 KM	DYM=	2.98694919E 00 KM/S
ZM=	-1.53752940E 05 KM	DZM=	1.64946855E 00 KM/S

G.M.T.=00:35:00.000 APRIL 12

R=	4.86375541E 04 KM	VEL=	3.86244223E 00 KM/S
DECL=	3.04064340E 01 DEG	EL=	6.75872734E 01 DEG
LONG=	-1.09633331E 02 DEG	AZ=	9.98270602E 01 DEG
X=	-6.50543863E 03 KM	DX=	-1.93081118E 00 KM/S
Y=	4.14402757E 04 KM	DY=	2.94293732E 00 KM/S
Z=	2.46169552E 04 KM	DZ=	1.59045530E 00 KM/S
XM=	1.83866006E 04 KM	DXM=	-9.47585408E-01 KM/S
YM=	-3.08421234E 05 KM	DYM=	2.94356816E 00 KM/S
ZM=	-1.53262006E 05 KM	DZM=	1.62363294E 00 KM/S

G.M.T.=00:40:00.000 APRIL 12

R=	4.97032481E 04 KM	VEL=	3.81667866E 00 KM/S
DECL=	3.03182277E 01 DEG	EL=	6.78164935E 01 DEG
LONG=	-1.10305457E 02 DEG	AZ=	1.00120944E 02 DEG
X=	-7.08366044E 03 KM	DX=	-1.92397800E 00 KM/S
Y=	4.23167915E 04 KM	DY=	2.90081072E 00 KM/S
Z=	2.50903126E 04 KM	DZ=	1.56545258E 00 KM/S
XM=	1.81033387E 04 KM	DXM=	-9.40804678E-01 KM/S
YM=	-3.07544428E 05 KM	DYM=	2.90211648E 00 KM/S
ZM=	-1.52778640E 05 KM	DZM=	1.59899280E 00 KM/S

G.M.T.=00:45:00.000 APRIL 12

R=	5.07581797E 04 KM	VEL=	3.77275720E 00 KM/S
DECL=	3.02312992E 01 DEG	EL=	6.80355635E 01 DEG
LONG=	-1.11002864E 02 DEG	AZ=	1.00401282E 02 DEG
X=	-7.55981333E 03 KM	DX=	-1.91702368E 00 KM/S
Y=	4.31809411E 04 KM	DY=	2.86047486E 00 KM/S
Z=	2.55563375E 04 KM	DZ=	1.54155788E 00 KM/S
XM=	1.78221298E 04 KM	DXM=	-9.33903366E-01 KM/S
YM=	-3.06679785E 05 KM	DYM=	2.86245546E 00 KM/S
ZM=	-1.52302499E 05 KM	DZM=	1.57546063E 00 KM/S

G.M.T.=00:50:00.000 APRIL 12

R=	5.18027168E 04 KM	VEL=	3.73055224E 00 KM/S
DECL=	3.01456908E 01 DEG	EL=	6.82452060E 01 DEG
LONG=	-1.11723739E 02 DEG	AZ=	1.00669084E 02 DEG
X=	-8.23386549E 03 KM	DX=	-1.90997762E 00 KM/S
Y=	4.40332429E 04 KM	DY=	2.82180492E 00 KM/S
Z=	2.60153501E 04 KM	DZ=	1.51869104E 00 KM/S
XM=	1.75430055E 04 KM	DXM=	-9.26910868E-01 KM/S
YM=	-3.05826788E 05 KM	DYM=	2.82446031E 00 KM/S
ZM=	-1.61833261E 05 KM	DZM=	1.55295626E 00 KM/S

G.M.T.=00:55:00.000 APRIL 12

R=	5.28372060E 04 KM	VEL=	3.68994997E 00 KM/S
DECL=	3.00614298E 01 DEG	EL=	6.84460740E 01 DEG
LONG=	-1.12466449E 02 DEG	AZ=	1.00925253E 02 DEG
X=	-8.80579324E 03 KM	DX=	-1.90286471E 00 KM/S
Y=	4.48741794E 04 KM	DY=	2.78468784E 00 KM/S
Z=	2.64676477E 04 KM	DZ=	1.49678000E 00 KM/S
XM=	1.72659898E 04 KM	DXM=	-9.19852074E-01 KM/S
YM=	-3.04984954E 05 KM	DYM=	2.78801795E 00 KM/S
ZM=	-1.61370630E 05 KM	DZM=	1.53140763E 00 KM/S

G.M.T.=01:00:00.000 APRIL 12

R=	5.38619747E 04 KM	VEL=	3.65084705E 00 KM/S
DECL=	2.99785312E 01 DEG	EL=	6.86387598E 01 DEG
LONG=	-1.13229513E 02 DEG	AZ=	1.01170594E 02 DEG
X=	-9.37557976E 03 KM	DX=	-1.89570605E 00 KM/S
Y=	4.57042006E 04 KM	DY=	2.74902090E 00 KM/S
Z=	2.69135072E 04 KM	DZ=	1.47575976E 00 KM/S
XM=	1.69910987E 04 KM	DXM=	-9.12748086E-01 KM/S
YM=	-3.04153832E 05 KM	DYM=	2.75302566E 00 KM/S
ZM=	-1.60914328E 05 KM	DZM=	1.51074974E 00 KM/S

G.M.T.=01:05:00.000 APRIL 12

R=	5.48773319E 04 KM	VEL=	3.61314929E 00 KM/S
DECL=	2.98970007E 01 DEG	EL=	6.88238009E 01 DEG
LONG=	-1.14011587E 02 DEG	AZ=	1.01405839E 02 DEG
X=	-9.94321409E 03 KM	DX=	-1.88851955E 00 KM/S
Y=	4.65237275E 04 KM	DY=	2.71471065E 00 KM/S
Z=	2.73531867E 04 KM	DZ=	1.45557129E 00 KM/S
XM=	1.67183433E 04 KM	DXM=	-9.05616821E-01 KM/S
YM=	-3.03333003E 05 KM	DYM=	2.71938999E 00 KM/S
ZM=	-1.60464097E 05 KM	DZM=	1.49092358E 00 KM/S

G.M.T.=01:10:00.000 APRIL 12

R= 5.58835701E 04 KM	VEL= 3.57677070E 00 KM/S
DECL= 2.98168362E 01 DEG	EL= 6.90016865E 01 DEG
LONG=-1.14811449E 02 DEG	AZ= 1.01631652E 02 DEG
X=-1.05086902E 04 KM	DX=-1.88132045E 00 KM/S
Y= 4.73331541E 04 KM	DY= 2.68167185E 00 KM/S
Z= 2.77869277E 04 KM	DZ= 1.43616089E 00 KM/S
XM= 1.54477297E 04 KM	DXM=-8.98473507E-01 KM/S
YM=-3.02522071E 05 KM	DYM= 2.68702570E 00 KM/S
ZM=-1.50019696E 05 KM	DZM= 1.47187543E 00 KM/S

LUNAR IMPACT BURN, APS ENGINES ON

G.M.T.=01:12:59.500 APRIL 12

R= 5.54813909E 04 KM	VEL= 3.55560207E 00 KM/S
DECL= 2.97695212E 01 DEG	EL= 6.91048865E 01 DEG
LONG=-1.15298072E 02 DEG	AZ= 1.01762507E 02 DEG
X=-1.08460006E 04 KM	DX=-1.87701240E 00 KM/S
Y= 4.78127854E 04 KM	DY= 2.66247903E 00 KM/S
Z= 2.80437040E 04 KM	DZ= 1.42489857E 00 KM/S
XM= 1.52868372E 04 KM	DXM=-8.94199105E-01 KM/S
YM=-3.02041443E 05 KM	DYM= 2.66823643E 00 KM/S
ZM=-1.59756489E 05 KM	DZM= 1.46082983E 00 KM/S

LUNAR IMPACT BURN, APS ENGINES OFF

G.M.T.=01:16:36.500 APRIL 12

R= 5.71999183E 04 KM	VEL= 3.52707340E 00 KM/S
DECL= 2.97133377E 01 DEG	EL= 6.93606055E 01 DEG
LONG=-1.15895187E 02 DEG	AZ= 1.01858166E 02 DEG
X=-1.12517017E 04 KM	DX=-1.86304630E 00 KM/S
Y= 4.83880927E 04 KM	DY= 2.63998169E 00 KM/S
Z= 2.83517608E 04 KM	DZ= 1.41414354E 00 KM/S
XM= 1.50944022E 04 KM	DXM=-8.80273947E-01 KM/S
YM=-3.01464833E 05 KM	DYM= 2.64622691E 00 KM/S
ZM=-1.59440607E 05 KM	DZM= 1.45033676E 00 KM/S

G.M.T.=01:30:00.000 APRIL 12

R= 5.98222107E 04 KM	VEL= 3.43938272E 00 KM/S
DECL= 2.95124196E 01 DEG	EL= 6.97799693E 01 DEG
LONG=-1.18176495E 02 DEG	AZ= 1.02389800E 02 DEG
X=-1.27409440E 04 KM	DX=-1.84387455E 00 KM/S
Y= 5.04770676E 04 KM	DY= 2.56092191E 00 KM/S
Z= 2.94691513E 04 KM	DZ= 1.36790318E 00 KM/S
XM= 1.53947555E 04 KM	DXM=-8.61256320E-01 KM/S
YM=-2.99370115E 05 KM	DYM= 2.56897313E 00 KM/S
ZM=-1.58293746E 05 KM	DZM= 1.40506615E 00 KM/S

G.M.T.=02:00:00.000 APRIL 12

R= 6.54968353E 04 KM	VEL= 3.26724095E 00 KM/S
DECL= 2.90947289E 01 DEG	EL= 7.05908666E 01 DEG
LONG=-1.23606183E 02 DEG	AZ= 1.03413333E 02 DEG
X=-1.50219603E 04 KM	DX=-1.80199907E 00 KM/S
Y= 5.49438507E 04 KM	DY= 2.40696995E 00 KM/S
Z= 3.18481631E 04 KM	DZ= 1.27834207E 00 KM/S
XM= 1.38821310E 04 KM	DXM=-8.19740557E-01 KM/S
YM=-2.94885200E 05 KM	DYM= 2.41906510E 00 KM/S
ZM=-1.55845887E 05 KM	DZM= 1.31767596E 00 KM/S

G.M.T.=02:30:00.000 APRIL 12

R= 7.09279549E 04 KM	VEL= 3.12136917E 00 KM/S
DECL= 2.87173555E 01 DEG	EL= 7.12642662E 01 DEG
LONG=-1.29376612E 02 DEG	AZ= 1.04259466E 02 DEG
X=-1.92293908E 04 KM	DX=-1.76218824E 00 KM/S
Y= 5.91570040E 04 KM	DY= 2.27786408E 00 KM/S
Z= 3.40801144E 04 KM	DZ= 1.20373309E 00 KM/S
XM= 1.24424266E 04 KM	DXM=-7.80309412E-01 KM/S
YM=-2.90646638E 05 KM	DYM= 2.29400058E 00 KM/S
ZM=-1.53541182E 05 KM	DZM= 1.24523583E 00 KM/S

G.M.T.=03:00:00.000 APRIL 12

R= 7.51477532E 04 KM	VEL= 2.99542731E 00 KM/S
DECL= 2.83748225E 01 DEG	EL= 7.18345799E 01 DEG
LONG=-1.35402039E 02 DEG	AZ= 1.04974100E 02 DEG
X=-2.23672248E 04 KM	DX=-1.72468099E 00 KM/S
Y= 6.31553338E 04 KM	DY= 2.16744177E 00 KM/S
Z= 3.51882770E 04 KM	DZ= 1.14028787E 00 KM/S
XM= 1.10716174E 04 KM	DXM=-7.43201775E-01 KM/S
YM=-2.86615627E 05 KM	DYM= 2.18761697E 00 KM/S
ZM=-1.51356364E 05 KM	DZM= 1.18395733E 00 KM/S

G.M.T.=03:30:00.000 APRIL 12

R= 8.11815645E 04 KM	VEL= 2.88505191E 00 KM/S
DECL= 2.80622523E 01 DEG	EL= 7.23252091E 01 DEG
LONG=-1.41624276E 02 DEG	AZ= 1.05588164E 02 DEG
X=-2.54396140E 04 KM	DX=-1.68945657E 00 KM/S
Y= 6.69684550E 04 KM	DY= 2.07149343E 00 KM/S
Z= 3.81902933E 04 KM	DZ= 1.08543814E 00 KM/S
XM= 9.76551592E 03 KM	DXM=-7.08396870E-01 KM/S
YM=-2.82762558E 05 KM	DYM= 2.09570460E 00 KM/S
ZM=-1.49273795E 05 KM	DZM= 1.13127218E 00 KM/S

G.M.T.=04:00:00.000 APRIL 12

R=	8.50497755E 04 KM	VEL=	2.78712515E 00 KM/S
DECL=	2.77755017E 01 DEG	EL=	7.27527026E 01 DEG
LONG=	-1.48002260E 02 DEG	AZ=	1.06123327E 02 DEG
X=	-2.84505631E 04 KM	DX=	-1.65638880E 00 KM/S
Y=	7.06195870E 04 KM	DY=	1.98703260E 00 KM/S
Z=	4.00999158E 04 KM	DZ=	1.03737371E 00 KM/S
XM=	8.52008148E 03 KM	DXM=	-6.75768472E-01 KM/S
YM=	-2.79064215E 05 KM	DYM=	2.01527695E 00 KM/S
ZM=	-1.47279725E 05 KM	DZM=	1.08537013E 00 KM/S

G.M.T.=04:30:00.000 APRIL 12

R=	9.07690965E 04 KM	VEL=	2.69934987E 00 KM/S
DECL=	2.75111081E 01 DEG	EL=	7.31291427E 01 DEG
LONG=	-1.54506067E 02 DEG	AZ=	1.06595267E 02 DEG
X=	-3.14038097E 04 KM	DX=	-1.62531432E 00 KM/S
Y=	7.41273428E 04 KM	DY=	1.91187371E 00 KM/S
Z=	4.19281129E 04 KM	DZ=	9.94777368E-01 KM/S
XM=	7.33154089E 03 KM	DXM=	-6.45153207E-01 KM/S
YM=	-2.75501992E 05 KM	DYM=	1.94414839E 00 KM/S
ZM=	-1.45363190E 05 KM	DZM=	1.04493394E 00 KM/S

G.M.T.=05:00:00.000 APRIL 12

R=	9.53534400E 04 KM	VEL=	2.61998971E 00 KM/S
DECL=	2.72661869E 01 DEG	EL=	7.34635873E 01 DEG
LONG=	-1.51113304E 02 DEG	AZ=	1.07015639E 02 DEG
X=	-3.43027886E 04 KM	DX=	-1.59606338E 00 KM/S
Y=	7.75069211E 04 KM	DY=	1.84437529E 00 KM/S
Z=	4.36838001E 04 KM	DZ=	9.56664821E-01 KM/S
XM=	6.19642366E 03 KM	DXM=	-6.16381281E-01 KM/S
YM=	-2.72060694E 05 KM	DYM=	1.88067736E 00 KM/S
ZM=	-1.43515278E 05 KM	DZM=	1.00897929E 00 KM/S

G.M.T.=05:30:00.000 APRIL 12

R=	9.98145452E 04 KM	VEL=	2.54770354E 00 KM/S
DECL=	2.70383303E 01 DEG	EL=	7.37629814E 01 DEG
LONG=	-1.57806829E 02 DEG	AZ=	1.07393304E 02 DEG
X=	-3.71506342E 04 KM	DX=	-1.56847333E 00 KM/S
Y=	8.07709286E 04 KM	DY=	1.78327712E 00 KM/S
Z=	4.53743420E 04 KM	DZ=	9.22283828E-01 KM/S
XM=	5.11155976E 03 KM	DXM=	-5.89290021E-01 KM/S
YM=	-2.68727721E 05 KM	DYM=	1.82360360E 00 KM/S
ZM=	-1.41728630E 05 KM	DZM=	9.76753894E-01 KM/S

G.M.T.=06:00:00.000 APRIL 12

R=	1.04162433E 05 KM	VEL=	2.48143612E 00 KM/S
DECL=	2.58255191E 01 DEG	EL=	7.40327522E 01 DEG
LONG=	-1.74573265E 02 DEG	AZ=	1.07735137E 02 DEG
X=	-3.99501988E 04 KM	DX=	-1.54239413E 00 KM/S
Y=	8.39299634E 04 KM	DY=	1.72759327E 00 KM/S
Z=	4.70059067E 04 KM	DZ=	8.91048292E-01 KM/S
XM=	4.07406123E 03 KM	DXM=	-5.63729342E-01 KM/S
YM=	-2.55492478E 05 KM	DYM=	1.77194110E 00 KM/S
ZM=	-1.39997081E 05 KM	DZM=	9.47671626E-01 KM/S

G.M.T.=06:30:00.000 APRIL 12

R=	1.08405744E 05 KM	VEL=	2.42034370E 00 KM/S
DECL=	2.56260500E 01 DEG	EL=	7.42772122E 01 DEG
LONG=	1.78598005E 02 DEG	AZ=	1.08046559E 02 DEG
X=	-4.27040777E 04 KM	DX=	-1.51768993E 00 KM/S
Y=	8.59930395E 04 KM	DY=	1.67653967E 00 KM/S
Z=	4.95837227E 04 KM	DZ=	8.62493863E-01 KM/S
XM=	3.08129744E 03 KM	DXM=	-5.39563371E-01 KM/S
YM=	-2.52345959E 05 KM	DYM=	1.72490572E 00 KM/S
ZM=	-1.38315407E 05 KM	DZM=	9.21268099E-01 KM/S

G.M.T.=07:00:00.000 APRIL 12

R=	1.12551996E 05 KM	VEL=	2.36374210E 00 KM/S
DECL=	2.54384772E 01 DEG	EL=	7.44998378E 01 DEG
LONG=	1.71715532E 02 DEG	AZ=	1.08331909E 02 DEG
X=	-4.54146342E 04 KM	DX=	-1.49423893E 00 KM/S
Y=	8.99679025E 04 KM	DY=	1.62948376E 00 KM/S
Z=	5.01122680E 04 KM	DZ=	8.36247227E-01 KM/S
XM=	2.13086955E 03 KM	DXM=	-5.16670280E-01 KM/S
YM=	-2.59280423E 05 KM	DYM=	1.68186484E 00 KM/S
ZM=	-1.36679134E 05 KM	DZM=	8.97169963E-01 KM/S

G.M.T.=07:30:00.000 APRIL 12

R=	1.16607784E 05 KM	VEL=	2.31106961E 00 KM/S
DECL=	2.52615658E 01 DEG	EL=	7.47034677E 01 DEG
LONG=	1.64786289E 02 DEG	AZ=	1.08594711E 02 DEG
X=	-4.80840244E 04 KM	DX=	-1.47193245E 00 KM/S
Y=	9.28612678E 04 KM	DY=	1.58590874E 00 KM/S
Z=	5.15954139E 04 KM	DZ=	8.12004358E-01 KM/S
XM=	1.22058619E 03 KM	DXM=	-4.94941336E-01 KM/S
YM=	-2.56289161E 05 KM	DYM=	1.64230159E 00 KM/S
ZM=	-1.35084395E 05 KM	DZM=	8.75073159E-01 KM/S

G.M.T.=08:00:00.000 APRIL 12

R=	1.20578929E 05 KM	VEL=	2.26185994E 00 KM/S
DECL=	2.50942543E 01 DEG	EL=	7.48904463E 01 DEG
LONG=	1.57816033E 02 DEG	AZ=	1.08837855E 02 DEG
X=	-5.07142194E 04 KM	DX=	-1.45067361E 00 KM/S
Y=	9.56790049E 04 KM	DY=	1.54538761E 00 KM/S
Z=	5.30365348E 04 KM	DZ=	7.89514798E-01 KM/S
XM=	3.48440750E 02 KM	DXM=	-4.74279646E-01 KM/S
YM=	-2.53366308E 05 KM	DYM=	1.60578890E 00 KM/S
ZM=	-1.33527821E 05 KM	DZM=	8.54727194E-01 KM/S

G.M.T.=08:30:00.000 APRIL 12

R=	1.24470608E 05 KM	VEL=	2.21572220E 00 KM/S
DECL=	2.59356254E 01 DEG	EL=	7.50627292E 01 DEG
LONG=	1.50809561E 02 DEG	AZ=	1.09063738E 02 DEG
X=	-5.33070260E 04 KM	DX=	-1.43037610E 00 KM/S
Y=	9.84262806E 04 KM	DY=	1.50756396E 00 KM/S
Z=	5.44385934E 04 KM	DZ=	7.68570089E-01 KM/S
XM=	-4.87408678E 02 KM	DXM=	-4.54598864E-01 KM/S
YM=	-2.50506705E 05 KM	DYM=	1.57197031E 00 KM/S
ZM=	-1.32006452E 05 KM	DZM=	8.35923575E-01 KM/S

G.M.T.=09:00:00.000 APRIL 12

R=	1.28287448E 05 KM	VEL=	2.17232578E 00 KM/S
DECL=	2.57848815E 01 DEG	EL=	7.52219632E 01 DEG
LONG=	1.43770912E 02 DEG	AZ=	1.09274368E 02 DEG
X=	-5.58641038E 04 KM	DX=	-1.41096292E 00 KM/S
Y=	1.01107673E 05 KM	DY=	1.47213765E 00 KM/S
Z=	5.58042084E 04 KM	DZ=	7.48995121E-01 KM/S
XM=	-1.28865701E 03 KM	DXM=	-4.35821948E-01 KM/S
YM=	-2.47705779E 05 KM	DYM=	1.54054559E 00 KM/S
ZM=	-1.30517676E 05 KM	DZM=	8.18487157E-01 KM/S

G.M.T.=09:30:00.000 APRIL 12

R=	1.32033607E 05 KM	VEL=	2.13138879E 00 KM/S
DECL=	2.56413257E 01 DEG	EL=	7.53695461E 01 DEG
LONG=	1.36703511E 02 DEG	AZ=	1.09471441E 02 DEG
X=	-5.83869816E 04 KM	DX=	-1.39236523E 00 KM/S
Y=	1.03727261E 05 KM	DY=	1.43885376E 00 KM/S
Z=	5.71357083E 04 KM	DZ=	7.30641558E-01 KM/S
XM=	-2.05686790E 03 KM	DXM=	-4.17880037E-01 KM/S
YM=	-2.44959458E 05 KM	DYM=	1.51125978E 00 KM/S
ZM=	-1.29059168E 05 KM	DZM=	8.02269571E-01 KM/S

G.M.T.=10:00:00.000 APRIL 12

R=	1.35712841E 05 KM	VEL=	2.09266913E 00 KM/S
DECL=	2.55043458E 01 DEG	EL=	7.55066736E 01 DEG
LONG=	1.29610288E 02 DEG	AZ=	1.09656401E 02 DEG
X=	-6.08770708E 04 KM	DX=	-1.37452139E 00 KM/S
Y=	1.06288700E 05 KM	DY=	1.40749424E 00 KM/S
Z=	5.94351746E 04 KM	DZ=	7.13382787E-01 KM/S
XM=	-2.79348827E 03 KM	DXM=	-4.00711442E-01 KM/S
YM=	-2.42264092E 05 KM	DYM=	1.48389475E 00 KM/S
ZM=	-1.27628850E 05 KM	DZM=	7.87144170E-01 KM/S

G.M.T.=10:30:00.000 APRIL 12

R=	1.39328554E 05 KM	VEL=	2.05595749E 00 KM/S
DECL=	2.53734017E 01 DEG	EL=	7.56343753E 01 DEG
LONG=	1.22493765E 02 DEG	AZ=	1.09830484E 02 DEG
X=	-6.33356776E 04 KM	DX=	-1.35737603E 00 KM/S
Y=	1.08795281E 05 KM	DY=	1.37787124E 00 KM/S
Z=	5.97044776E 04 KM	DZ=	6.97109987E-01 KM/S
XM=	-3.49985893E 03 KM	DXM=	-3.84260771E-01 KM/S
YM=	-2.39616397E 05 KM	DYM=	1.45826259E 00 KM/S
ZM=	-1.26224859E 05 KM	DZM=	7.73002098E-01 KM/S

G.M.T.=11:00:00.000 APRIL 12

R=	1.42883848E 05 KM	VEL=	2.02107178E 00 KM/S
DECL=	2.52480149E 01 DEG	EL=	7.57535439E 01 DEG
LONG=	1.15356125E 02 DEG	AZ=	1.09994758E 02 DEG
X=	-6.57640136E 04 KM	DX=	-1.34087932E 00 KM/S
Y=	1.11249980E 05 KM	DY=	1.34982196E 00 KM/S
Z=	6.09453054E 04 KM	DZ=	6.81729028E-01 KM/S
XM=	-4.17722693E 03 KM	DXM=	-3.68478156E-01 KM/S
YM=	-2.37013404E 05 KM	DYM=	1.43420042E 00 KM/S
ZM=	-1.24845509E 05 KM	DZM=	7.59749191E-01 KM/S

G.M.T.=11:30:00.000 APRIL 12

R=	1.46381559E 05 KM	VEL=	1.98785273E 00 KM/S
DECL=	2.51277595E 01 DEG	EL=	7.58649571E 01 DEG
LONG=	1.08199274E 02 DEG	AZ=	1.10150149E 02 DEG
X=	-6.81632053E 04 KM	DX=	-1.32498629E 00 KM/S
Y=	1.13655499E 05 KM	DY=	1.32320444E 00 KM/S
Z=	6.21591879E 04 KM	DZ=	6.67158012E-01 KM/S
XM=	-4.82675311E 03 KM	DXM=	-3.53318587E-01 KM/S
YM=	-2.34452418E 05 KM	DYM=	1.41156624E 00 KM/S
ZM=	-1.23489277E 05 KM	DZM=	7.47303519E-01 KM/S

G.M.T.=12:00:00.000 APRIL 12

R=	1.49824276E 05 KM	VEL=	1.95616027E 00 KM/S
DECL=	2.30122550E 01 DEG	EL=	7.59692968E 01 DEG
LONG=	1.01024878E 02 DEG	AZ=	1.10297467E 02 DEG
X=	-7.05343020E 04 KM	DX=	-1.30965623E 00 KM/S
Y=	1.16014301E 05 KM	DY=	1.29789430E 00 KM/S
Z=	6.33475170E 04 KM	DZ=	6.53325298E-01 KM/S
XM=	-5.44952216E 03 KM	DXM=	-3.38741338E-01 KM/S
YM=	-2.31930983E 05 KM	DYM=	1.39023560E 00 KM/S
ZM=	-1.22154775E 05 KM	DZM=	7.35593405E-01 KM/S

G.M.T.=12:30:00.000 APRIL 12

R=	1.53214400E 05 KM	VEL=	1.92587067E 00 KM/S
DECL=	2.49011603E 01 DEG	EL=	7.60671637E 01 DEG
LONG=	9.38344077E 01 DEG	AZ=	1.10437421E 02 DEG
X=	-7.28782833E 04 KM	DX=	-1.29485225E 00 KM/S
Y=	1.18328637E 05 KM	DY=	1.27378198E 00 KM/S
Z=	6.45115640E 04 KM	DZ=	6.40167904E-01 KM/S
XM=	-6.04654873E 03 KM	DXM=	-3.24709454E-01 KM/S
YM=	-2.29446854E 05 KM	DYM=	1.37009886E 00 KM/S
ZM=	-1.20840738E 05 KM	DZM=	7.24555835E-01 KM/S

G.M.T.=13:00:00.000 APRIL 12

R=	1.56554135E 05 KM	VEL=	1.89687408E 00 KM/S
DECL=	2.47941686E 01 DEG	EL=	7.61590890E 01 DEG
LONG=	8.66291609E 01 DEG	AZ=	1.10570636E 02 DEG
X=	-7.51960655E 04 KM	DX=	-1.28054076E 00 KM/S
Y=	1.20600576E 05 KM	DY=	1.25077054E 00 KM/S
Z=	6.56524932E 04 KM	DZ=	6.27630201E-01 KM/S
XM=	-6.51878349E 03 KM	DXM=	-3.11189342E-01 KM/S
YM=	-2.26997970E 05 KM	DYM=	1.35105902E 00 KM/S
ZM=	-1.19546005E 05 KM	DZM=	7.14135146E-01 KM/S

G.M.T.=13:30:00.000 APRIL 12

R=	1.59845520E 05 KM	VEL=	1.86907263E 00 KM/S
DECL=	2.46910028E 01 DEG	EL=	7.62455452E 01 DEG
LONG=	7.94102923E 01 DEG	AZ=	1.10697667E 02 DEG
X=	-7.74885072E 04 KM	DX=	-1.26669119E 00 KM/S
Y=	1.22832020E 05 KM	DY=	1.22877387E 00 KM/S
Z=	6.57713748E 04 KM	DZ=	6.15662845E-01 KM/S
XM=	-7.16711949E 03 KM	DXM=	-2.98150372E-01 KM/S
YM=	-2.24582435E 05 KM	DYM=	1.33302992E 00 KM/S
ZM=	-1.18269511E 05 KM	DZM=	7.04281960E-01 KM/S

G.M.T.=14:00:00.000 APRIL 12

R=	1.53090450E 05 KM	VEL=	1.84237877E 00 KM/S
DECL=	2.45914123E 01 DEG	EL=	7.63269537E 01 DEG
LONG=	7.21788311E 01 DEG	AZ=	1.10819006E 02 DEG
X=	-7.97564141E 04 KM	DX=	-1.25327556E 00 KM/S
Y=	1.25024725E 05 KM	DY=	1.20771512E 00 KM/S
Z=	6.78691952E 04 KM	DZ=	6.04221888E-01 KM/S
XM=	-7.59239694E 03 KM	DXM=	-2.85564560E-01 KM/S
YM=	-2.22198502E 05 KM	DYM=	1.31593464E 00 KM/S
ZM=	-1.17010276E 05 KM	DZM=	6.94952297E-01 KM/S

G.M.T.=14:30:00.000 APRIL 12

R=	1.56290686E 05 KM	VEL=	1.81671387E 00 KM/S
DECL=	2.44951694E 01 DEG	EL=	7.64036921E 01 DEG
LONG=	6.49356993E 01 DEG	AZ=	1.10935092E 02 DEG
X=	-8.20005442E 04 KM	DX=	-1.24026830E 00 KM/S
Y=	1.27180316E 05 KM	DY=	1.18752552E 00 KM/S
Z=	6.89468658E 04 KM	DZ=	5.93268040E-01 KM/S
XM=	-8.19540857E 03 KM	DXM=	-2.73406273E-01 KM/S
YM=	-2.19844552E 05 KM	DYM=	1.29970434E 00 KM/S
ZM=	-1.15767393E 05 KM	DZM=	6.86106834E-01 KM/S

START OF ANOMALOUS APS THRUSTING

G.M.T.=14:42:10.000 APRIL 12

R=	1.57576197E 05 KM	VEL=	1.80658219E 00 KM/S
DECL=	2.44570437E 01 DEG	EL=	7.64335614E 01 DEG
LONG=	6.19950776E 01 DEG	AZ=	1.10980766E 02 DEG
X=	-8.29040498E 04 KM	DX=	-1.23510410E 00 KM/S
Y=	1.28044296E 05 KM	DY=	1.17957091E 00 KM/S
Z=	6.93783725E 04 KM	DZ=	5.88956306E-01 KM/S
XM=	-8.39323361E 03 KM	DXM=	-2.68591830E-01 KM/S
YM=	-2.18898095E 05 KM	DYM=	1.29335425E 00 KM/S
ZM=	-1.15267803E 05 KM	DZM=	6.82649330E-01 KM/S

END OF ANOMALOUS APS THRUSTING

G.M.T.=14:44:34.000 APRIL 12

R=	1.57502373E 05 KM	VEL=	1.80630234E 00 KM/S
DECL=	2.44583586E 01 DEG	EL=	7.64417397E 01 DEG
LONG=	6.14370742E 01 DEG	AZ=	1.10913477E 02 DEG
X=	-8.29641188E 04 KM	DX=	-1.23566126E 00 KM/S
Y=	1.27923399E 05 KM	DY=	1.17832020E 00 KM/S
Z=	6.93513076E 04 KM	DZ=	5.89432693E-01 KM/S
XM=	-8.31412978E 03 KM	DXM=	-2.69218358E-01 KM/S
YM=	-2.19002585E 05 KM	DYM=	1.29241996E 00 KM/S
ZM=	-1.15281364E 05 KM	DZM=	6.83294165E-01 KM/S

G.M.T.=15:00:00.000 APRIL 12

R=	1.59122812E 05 KM	VEL=	1.79365851E 00 KM/S
DECL=	2.44108794E 01 DEG	EL=	7.64785518E 01 DEG
LONG=	5.77044460E 01 DEG	AZ=	1.10970311E 02 DEG
X=	-8.41053356E 04 KM	DX=	-1.22918608E 00 KM/S
Y=	1.29009920E 05 KM	DY=	1.16841104E 00 KM/S
Z=	6.98946267E 04 KM	DZ=	5.84061690E-01 KM/S
XM=	-8.56062795E 03 KM	DXM=	-2.63192158E-01 KM/S
YM=	-2.17809466E 05 KM	DYM=	1.28454494E 00 KM/S
ZM=	-1.14650627E 05 KM	DZM=	6.79005926E-01 KM/S

G.M.T.=16:00:00.000 APRIL 12

R=	1.75319581E 05 KM	VEL=	1.74669269E 00 KM/S
DECL=	2.42335066E 01 DEG	EL=	7.66118400E 01 DEG
LONG=	4.31684698E 01 DEG	AZ=	1.11180276E 02 DEG
X=	-8.34862890E 04 KM	DX=	-1.20490756E 00 KM/S
Y=	1.33149319E 05 KM	DY=	1.13172549E 00 KM/S
Z=	7.19610391E 04 KM	DZ=	5.64207890E-01 KM/S
XM=	-9.46720893E 03 KM	DXM=	-2.40707109E-01 KM/S
YM=	-2.13237766E 05 KM	DYM=	1.25575660E 00 KM/S
ZM=	-1.12234849E 05 KM	DZM=	6.63354055E-01 KM/S

G.M.T.=17:00:00.000 APRIL 12

R=	1.81360725E 05 KM	VEL=	1.70288479E 00 KM/S
DECL=	2.40666352E 01 DEG	EL=	7.67310459E 01 DEG
LONG=	2.85970039E 01 DEG	AZ=	1.11374540E 02 DEG
X=	-9.27822419E 04 KM	DX=	-1.18193974E 00 KM/S
Y=	1.37161512E 05 KM	DY=	1.09768255E 00 KM/S
Z=	7.39586905E 04 KM	DZ=	5.45827893E-01 KM/S
XM=	-1.02953828E 04 KM	DXM=	-2.19608868E-01 KM/S
YM=	-2.08764872E 05 KM	DYM=	1.22959322E 00 KM/S
ZM=	-1.09872727E 05 KM	DZM=	6.49163825E-01 KM/S

G.M.T.=18:00:00.000 APRIL 12

R=	1.87256127E 05 KM	VEL=	1.66186248E 00 KM/S
DECL=	2.39091383E 01 DEG	EL=	7.68379401E 01 DEG
LONG=	1.39943506E 01 DEG	AZ=	1.11555127E 02 DEG
X=	-9.69976683E 04 KM	DX=	-1.16015015E 00 KM/S
Y=	1.41055417E 05 KM	DY=	1.06596106E 00 KM/S
Z=	7.58925487E 04 KM	DZ=	5.28739596E-01 KM/S
XM=	-1.10498970E 04 KM	DXM=	-1.99764686E-01 KM/S
YM=	-2.04381933E 05 KM	DYM=	1.20573312E 00 KM/S
ZM=	-1.07559336E 05 KM	DZM=	6.36252875E-01 KM/S

G.M.T.=19:00:00.000 APRIL 12

R=	1.93014560E 05 KM	VEL=	1.62331365E 00 KM/S
DECL=	2.37600565E 01 DEG	EL=	7.69340052E 01 DEG
LONG=	-6.35899231E-01 DEG	AZ=	1.11723721E 02 DEG
X=	-1.01136599E 05 KM	DX=	-1.13942478E 00 KM/S
Y=	1.44838894E 05 KM	DY=	1.03629307E 00 KM/S
Z=	7.77669828E 04 KM	DZ=	5.12791440E-01 KM/S
XM=	-1.17350555E 04 KM	DXM=	-1.81060256E-01 KM/S
YM=	-2.00081153E 05 KM	DYM=	1.18390787E 00 KM/S
ZM=	-1.05290354E 05 KM	DZM=	6.24469387E-01 KM/S

G.M.T.=20:00:00.000 APRIL 12

R=	1.98643861E 05 KM	VEL=	1.58697433E 00 KM/S
DECL=	2.36185672E 01 DEG	EL=	7.70204955E 01 DEG
LONG=	-1.52907213E 01 DEG	AZ=	1.11881737E 02 DEG
X=	-1.05202685E 05 KM	DX=	-1.11966483E 00 KM/S
Y=	1.48518919E 05 KM	DY=	1.00845301E 00 KM/S
Z=	7.95858617E 04 KM	DZ=	4.97856113E-01 KM/S
XM=	-1.23547788E 04 KM	DXM=	-1.63396507E-01 KM/S
YM=	-1.95855626E 05 KM	DYM=	1.16389141E 00 KM/S
ZM=	-1.03061958E 05 KM	DZM=	6.13685794E-01 KM/S

G.M.T.=21:00:00.000 APRIL 12

R=	2.04151066E 05 KM	VEL=	1.55261947E 00 KM/S
DECL=	2.34839600E 01 DEG	EL=	7.70984823E 01 DEG
LONG=	-2.99675470E 01 DEG	AZ=	1.12030372E 02 DEG
X=	-1.09199241E 05 KM	DX=	-1.10078421E 00 KM/S
Y=	1.52101718E 05 KM	DY=	9.82249442E-01 KM/S
Z=	8.13526322E 04 KM	DZ=	4.83825778E-01 KM/S
XM=	-1.29126545E 04 KM	DXM=	-1.46687055E-01 KM/S
YM=	-1.91699195E 05 KM	DYM=	1.14549181E 00 KM/S
ZM=	-1.00870747E 05 KM	DZM=	6.03794006E-01 KM/S

G.M.T.=22:00:00.000 APRIL 12

R=	2.09542527E 05 KM	VEL=	1.52005582E 00 KM/S
DECL=	2.33556178E 01 DEG	EL=	7.71688897E 01 DEG
LONG=	-4.46641783E 01 DEG	AZ=	1.12170652E 02 DEG
X=	-1.13129295E 05 KM	DX=	-1.08270746E 00 KM/S
Y=	1.55592881E 05 KM	DY=	9.57518654E-01 KM/S
Z=	8.30703824E 04 KM	DZ=	4.70608410E-01 KM/S
XM=	-1.34119787E 04 KM	DXM=	-1.30856150E-01 KM/S
YM=	-1.87606342E 05 KM	DYM=	1.12854486E 00 KM/S
ZM=	-9.87136815E 04 KM	DZM=	5.94701744E-01 KM/S

G.M.T.=23:00:00.000 APRIL 12

R=	2.14824003E 05 KM	VEL=	1.48911629E 00 KM/S
DECL=	2.32330013E 01 DEG	EL=	7.72325213E 01 DEG
LONG=	-5.93787211E 01 DEG	AZ=	1.12303459E 02 DEG
X=	-1.16995619E 05 KM	DX=	-1.06536811E 00 KM/S
Y=	1.58997450E 05 KM	DY=	9.34119732E-01 KM/S
Z=	8.47416930E 04 KM	DZ=	4.58124935E-01 KM/S
XM=	-1.38557916E 04 KM	DXM=	-1.15837021E-01 KM/S
YM=	-1.33572098E 05 KM	DYM=	1.11290918E 00 KM/S
ZM=	-9.65880298E 04 KM	DZM=	5.86329682E-01 KM/S

G.M.T.=00:00:00.000 APRIL 13

R=	2.20000740E 05 KM	VEL=	1.45965557E 00 KM/S
DECL=	2.31156368E 01 DEG	EL=	7.72900823E 01 DEG
LONG=	-7.41095336E 01 DEG	AZ=	1.12429561E 02 DEG
X=	-1.20800760E 05 KM	DX=	-1.04870729E 00 KM/S
Y=	1.52319994E 05 KM	DY=	9.11930635E-01 KM/S
Z=	8.53696802E 04 KM	DZ=	4.46306990E-01 KM/S
XM=	-1.42469072E 04 KM	DXM=	-1.01570526E-01 KM/S
YM=	-1.79591969E 05 KM	DYM=	1.09846224E 00 KM/S
ZM=	-9.44913255E 04 KM	DZM=	5.78609210E-01 KM/S

G.M.T.=01:00:00.000 APRIL 13

R=	2.25077532E 05 KM	VEL=	1.43154658E 00 KM/S
DECL=	2.30031062E 01 DEG	EL=	7.73421972E 01 DEG
LONG=	-8.98551841E 01 DEG	AZ=	1.12549626E 02 DEG
X=	-1.24547063E 05 KM	DX=	-1.03267269E 00 KM/S
Y=	1.55564674E 05 KM	DY=	8.90845082E-01 KM/S
Z=	8.79560304E 04 KM	DZ=	4.35095137E-01 KM/S
XM=	-1.45879391E 04 KM	DXM=	-8.80040287E-02 KM/S
YM=	-1.75661872E 05 KM	DYM=	1.08509729E 00 KM/S
ZM=	-9.24213330E 04 KM	DZM=	5.71480642E-01 KM/S

G.M.T.=02:00:00.000 APRIL 13

R=	2.30058779E 05 KM	VEL=	1.40467762E 00 KM/S
DECL=	2.28950388E 01 DEG	EL=	7.73894236E 01 DEG
LONG=	-1.03614418E 02 DEG	AZ=	1.12664245E 02 DEG
X=	-1.28236698E 05 KM	DX=	-1.01721757E 00 KM/S
Y=	1.58735291E 05 KM	DY=	8.70770056E-01 KM/S
Z=	8.95030299E 04 KM	DZ=	4.24437434E-01 KM/S
XM=	-1.48813203E 04 KM	DXM=	-7.50905161E-02 KM/S
YM=	-1.71778084E 05 KM	DYM=	1.07272084E 00 KM/S
ZM=	-9.03760172E 04 KM	DZM=	5.64891790E-01 KM/S

G.M.T.=03:00:00.000 APRIL 13

R=	2.34948530E 05 KM	VEL=	1.37895004E 00 KM/S
DECL=	2.27911047E 01 DEG	EL=	7.74322637E 01 DEG
LONG=	-1.18386129E 02 DEG	AZ=	1.12773941E 02 DEG
X=	-1.31871675E 05 KM	DX=	-1.00230004E 00 KM/S
Y=	1.71835333E 05 KM	DY=	8.51623772E-01 KM/S
Z=	9.10125899E 04 KM	DZ=	4.14288279E-01 KM/S
XM=	-1.51293243E 04 KM	DXM=	-6.27877978E-02 KM/S
YM=	-1.57937196E 05 KM	DYM=	1.06125062E 00 KM/S
ZM=	-8.33535193E 04 KM	DZM=	5.58796807E-01 KM/S

G.M.T.=04:00:00.000 APRIL 13

R=	2.39750527E 05 KM	VEL=	1.35427636E 00 KM/S
DECL=	2.26910088E 01 DEG	EL=	7.74711746E 01 DEG
LONG=	-1.33169341E 02 DEG	AZ=	1.12879181E 02 DEG
X=	-1.35453858E 05 KM	DX=	-9.87882406E-01 KM/S
Y=	1.74868010E 05 KM	DY=	8.33334028E-01 KM/S
Z=	9.24864674E 04 KM	DZ=	4.04607468E-01 KM/S
XM=	-1.53340802E 04 KM	DXM=	-5.10578774E-02 KM/S
YM=	-1.54136080E 05 KM	DYM=	1.05061398E 00 KM/S
ZM=	-8.63521356E 04 KM	DZM=	5.53155246E-01 KM/S

G.M.T.=05:00:00.000 APRIL 13

R=	2.44468237E 05 KM	VEL=	1.33057870E 00 KM/S
DECL=	2.25944870E 01 DEG	EL=	7.75065755E 01 DEG
LONG=	-1.47963184E 02 DEG	AZ=	1.12980384E 02 DEG
X=	-1.38984987E 05 KM	DX=	-9.73930621E-01 KM/S
Y=	1.77836289E 05 KM	DY=	8.15836845E-01 KM/S
Z=	9.39262829E 04 KM	DZ=	3.95359420E-01 KM/S
XM=	-1.54975875E 04 KM	DXM=	-3.98664126E-02 KM/S
YM=	-1.50371853E 05 KM	DYM=	1.04074646E 00 KM/S
ZM=	-8.43702997E 04 KM	DZM=	5.47931285E-01 KM/S

G.M.T.=06:00:00.000 APRIL 13

R=	2.49104879E 05 KM	VEL=	1.30778748E 00 KM/S
DECL=	2.25013012E 01 DEG	EL=	7.75388556E 01 DEG
LONG=	-1.52766884E 02 DEG	AZ=	1.13077931E 02 DEG
X=	-1.42466681E 05 KM	DX=	-9.60413843E-01 KM/S
Y=	1.80742918E 05 KM	DY=	7.99075346E-01 KM/S
Z=	9.53335364E 04 KM	DZ=	3.86512541E-01 KM/S
XM=	-1.56217275E 04 KM	DXM=	-2.91822582E-02 KM/S
YM=	-1.56641852E 05 KM	DYM=	1.03159072E 00 KM/S
ZM=	-8.24065666E 04 KM	DZM=	5.43093089E-01 KM/S

G.M.T.=07:00:00.000 APRIL 13

R=	2.53663454E 05 KM	VEL=	1.28584033E 00 KM/S
DECL=	2.24112368E 01 DEG	EL=	7.75683793E 01 DEG
LONG=	-1.77579749E 02 DEG	AZ=	1.13172167E 02 DEG
X=	-1.45900455E 05 KM	DX=	-9.47304039E-01 KM/S
Y=	1.33590453E 05 KM	DY=	7.82998818E-01 KM/S
Z=	9.57096207E 04 KM	DZ=	3.78038693E-01 KM/S
XM=	-1.57082747E 04 KM	DXM=	-1.89770763E-02 KM/S
YM=	-1.52943608E 05 KM	DYM=	1.02309559E 00 KM/S
ZM=	-8.04595996E 04 KM	DZM=	5.38612284E-01 KM/S

G.M.T.=08:00:00.000 APRIL 13

R=	2.58146765E 05 KM	VEL=	1.26468115E 00 KM/S
DECL=	2.23240998E 01 DEG	EL=	7.75954919E 01 DEG
LONG=	1.57598843E 02 DEG	AZ=	1.13263410E 02 DEG
X=	-1.49287727E 05 KM	DX=	-9.34575649E-01 KM/S
Y=	1.36381277E 05 KM	DY=	7.67561937E-01 KM/S
Z=	9.80558324E 04 KM	DZ=	3.69912753E-01 KM/S
XM=	-1.57589063E 04 KM	DXM=	-9.22500297E-03 KM/S
YM=	-1.49274826E 05 KM	DYM=	1.01521530E 00 KM/S
ZM=	-7.85281586E 04 KM	DZM=	5.34463508E-01 KM/S

G.M.T.=09:00:00.000 APRIL 13

R=	2.52557436E 05 KM	VEL=	1.24425941E 00 KM/S
DECL=	2.22397141E 01 DEG	EL=	7.76205243E 01 DEG
LONG=	1.52769452E 02 DEG	AZ=	1.13351954E 02 DEG
X=	-1.52629829E 05 KM	DX=	-9.22205303E-01 KM/S
Y=	1.39117618E 05 KM	DY=	7.52724114E-01 KM/S
Z=	9.93733829E 04 KM	DZ=	3.62112241E-01 KM/S
XM=	-1.57752100E 04 KM	DXM=	9.76387528E-05 KM/S
YM=	-1.45633369E 05 KM	DYM=	1.00790878E 00 KM/S
ZM=	-7.56110899E 04 KM	DZM=	5.30624046E-01 KM/S

G.M.T.=10:00:00.000 APRIL 13

R=	2.56897932E 05 KM	VEL=	1.22452944E 00 KM/S
DECL=	2.21579195E 01 DEG	EL=	7.76437972E 01 DEG
LONG=	1.37932582E 02 DEG	AZ=	1.13438075E 02 DEG
X=	-1.55928009E 05 KM	DX=	-9.10171571E-01 KM/S
Y=	1.91801565E 05 KM	DY=	7.38448940E-01 KM/S
Z=	1.00663407E 05 KM	DZ=	3.54617010E-01 KM/S
XM=	-1.57586923E 04 KM	DXM=	9.01258660E-03 KM/S
YM=	-1.42017238E 05 KM	DYM=	1.00113919E 00 KM/S
ZM=	-7.47073174E 04 KM	DZM=	5.27073518E-01 KM/S

G.M.T.=11:00:00.000 APRIL 13

R=	2.71170571E 05 KM	VEL=	1.20544989E 00 KM/S
DECL=	2.20785703E 01 DEG	EL=	7.76656253E 01 DEG
LONG=	1.23088691E 02 DEG	AZ=	1.13522031E 02 DEG
X=	-1.59183444E 05 KM	DX=	-8.98454748E-01 KM/S
Y=	1.94435086E 05 KM	DY=	7.24703728E-01 KM/S
Z=	1.01926970E 05 KM	DZ=	3.47408984E-01 KM/S
XM=	-1.57107843E 04 KM	DXM=	1.75398549E-02 KM/S
YM=	-1.38424561E 05 KM	DYM=	9.94873391E-01 KM/S
ZM=	-7.28158344E 04 KM	DZM=	5.23793614E-01 KM/S

G.M.T.=12:00:00.000 APRIL 13

R=	2.75377542E 05 KM	VEL=	1.18698326E 00 KM/S
DECL=	2.20015335E 01 DEG	EL=	7.76863213E 01 DEG
LONG=	1.08238192E 02 DEG	AZ=	1.13604070E 02 DEG
X=	-1.62397242E 05 KM	DX=	-8.87036667E-01 KM/S
Y=	1.97020033E 05 KM	DY=	7.11459117E-01 KM/S
Z=	1.03165077E 05 KM	DZ=	3.40471936E-01 KM/S
XM=	-1.56328480E 04 KM	DXM=	2.56979226E-02 KM/S
YM=	-1.34853580E 05 KM	DYM=	9.89081566E-01 KM/S
ZM=	-7.09356970E 04 KM	DZM=	5.20767876E-01 KM/S

G.M.T.=13:00:00.000 APRIL 13

R=	2.79520912E 05 KM	VEL=	1.16909552E 00 KM/S
DECL=	2.19266877E 01 DEG	EL=	7.77061997E 01 DEG
LONG=	9.33814601E 01 DEG	AZ=	1.13684428E 02 DEG
X=	-1.65570447E 05 KM	DX=	-8.75900531E-01 KM/S
Y=	1.99558160E 05 KM	DY=	6.98688747E-01 KM/S
Z=	1.04378676E 05 KM	DZ=	3.33791301E-01 KM/S
XM=	-1.55261815E 04 KM	DXM=	3.35039092E-02 KM/S
YM=	-1.31302637E 05 KM	DYM=	9.83736915E-01 KM/S
ZM=	-6.90660181E 04 KM	DZM=	5.17981511E-01 KM/S

G.M.T.=14:00:00.000 APRIL 13

R=	2.83602641E 05 KM	VEL=	1.15175573E 00 KM/S
DECL=	2.18539215E 01 DEG	EL=	7.77255806E 01 DEG
LONG=	7.85188383E 01 DEG	AZ=	1.13763337E 02 DEG
X=	-1.68704045E 05 KM	DX=	-8.65030771E-01 KM/S
Y=	2.02051132E 05 KM	DY=	6.86368980E-01 KM/S
Z=	1.05568666E 05 KM	DZ=	3.27354022E-01 KM/S
XM=	-1.53920233E 04 KM	DXM=	4.09736854E-02 KM/S
YM=	-1.27770167E 05 KM	DYM=	9.78815353E-01 KM/S
ZM=	-6.72059595E 04 KM	DZM=	5.15421230E-01 KM/S

G.M.T.=15:00:00.000 APRIL 13

R=	2.37624594E 05 KM	VEL=	1.13493577E 00 KM/S
DECL=	2.17831333E 01 DEG	EL=	7.77447939E 01 DEG
LONG=	6.36506371E 01 DEG	AZ=	1.13841026E 02 DEG
X=	-1.71798971E 05 KM	DX=	-8.54412915E-01 KM/S
Y=	2.04500532E 05 KM	DY=	6.74478669E-01 KM/S
Z=	1.06735902E 05 KM	DZ=	3.21148415E-01 KM/S
XM=	-1.52315567E 04 KM	DXM=	4.81220375E-02 KM/S
YM=	-1.24254666E 05 KM	DYM=	9.74295294E-01 KM/S
ZM=	-6.53547289E 04 KM	DZM=	5.13075124E-01 KM/S

G.M.T.=16:00:00.000 APRIL 13

R=	2.91588542E 05 KM	VEL=	1.11861009E 00 KM/S
DECL=	2.17142297E 01 DEG	EL=	7.77641836E 01 DEG
LONG=	4.37771401E 01 DEG	AZ=	1.13917721E 02 DEG
X=	-1.74856104E 05 KM	DX=	-8.44033475E-01 KM/S
Y=	2.06907871E 05 KM	DY=	6.62998968E-01 KM/S
Z=	1.07881200E 05 KM	DZ=	3.15164065E-01 KM/S
XM=	-1.50459139E 04 KM	DXM=	5.49627705E-02 KM/S
YM=	-1.20754783E 05 KM	DYM=	9.70157452E-01 KM/S
ZM=	-6.35115751E 04 KM	DZM=	5.10932549E-01 KM/S

G.M.T.=17:00:00.000 APRIL 13

R=	2.95496181E 05 KM	VEL=	1.10275547E 00 KM/S
DECL=	2.16471253E 01 DEG	EL=	7.77841124E 01 DEG
LONG=	3.38986052E 01 DEG	AZ=	1.13993654E 02 DEG
X=	-1.77876282E 05 KM	DX=	-8.33879839E-01 KM/S
Y=	2.09274597E 05 KM	DY=	6.51913181E-01 KM/S
Z=	1.09005338E 05 KM	DZ=	3.09391736E-01 KM/S
XM=	-1.48361783E 04 KM	DXM=	6.15088108E-02 KM/S
YM=	-1.17269115E 05 KM	DYM=	9.66384697E-01 KM/S
ZM=	-6.16757824E 04 KM	DZM=	5.08984048E-01 KM/S

G.M.T.=18:00:00.000 APRIL 13

R=	2.99349131E 05 KM	VEL=	1.08735090E 00 KM/S
DECL=	2.15817417E 01 DEG	EL=	7.78049670E 01 DEG
LONG=	1.90152681E 01 DEG	AZ=	1.14069061E 02 DEG
X=	-1.80860296E 05 KM	DX=	-8.23940185E-01 KM/S
Y=	2.11602101E 05 KM	DY=	6.41206643E-01 KM/S
Z=	1.10109065E 05 KM	DZ=	3.03823305E-01 KM/S
XM=	-1.46033892E 04 KM	DXM=	6.77723018E-02 KM/S
YM=	-1.13796394E 05 KM	DYM=	9.62961926E-01 KM/S
ZM=	-5.98466676E 04 KM	DZM=	5.07221269E-01 KM/S

G.M.T.=19:00:00.000 APRIL 13

R=	3.03148950E 05 KM	VEL=	1.07237740E 00 KM/S
DECL=	2.15180072E 01 DEG	EL=	7.78271638E 01 DEG
LONG=	4.12734312E 00 DEG	AZ=	1.14144190E 02 DEG
X=	-1.83808895E 05 KM	DX=	-8.14203387E-01 KM/S
Y=	2.13891725E 05 KM	DY=	6.30866629E-01 KM/S
Z=	1.11193102E 05 KM	DZ=	2.98451707E-01 KM/S
XM=	-1.43485429E 04 KM	DXM=	7.37646868E-02 KM/S
YM=	-1.10335385E 05 KM	DYM=	9.59875985E-01 KM/S
ZM=	-5.80235757E 04 KM	DZM=	5.05636928E-01 KM/S

G.M.T.=20:00:00.000 APRIL 13

R=	3.06897137E 05 KM	VEL=	1.05781788E 00 KM/S
DECL=	2.14558562E 01 DEG	EL=	7.78511558E 01 DEG
LONG=	-1.07649748E 01 DEG	AZ=	1.14219303E 02 DEG
X=	-1.86722791E 05 KM	DX=	-8.04658944E-01 KM/S
Y=	2.16144768E 05 KM	DY=	6.20882305E-01 KM/S
Z=	1.12258146E 05 KM	DZ=	2.93270905E-01 KM/S
XM=	-1.40725957E 04 KM	DXM=	7.94967896E-02 KM/S
YM=	-1.06884896E 05 KM	DYM=	9.57115607E-01 KM/S
ZM=	-5.62058756E 04 KM	DZM=	5.04224767E-01 KM/S

G.M.T.=21:00:00.000 APRIL 13

R=	3.10595141E 05 KM	VEL=	1.04365714E 00 KM/S
DECL=	2.13952289E 01 DEG	EL=	7.78774401E 01 DEG
LONG=	-2.56615086E 01 DEG	AZ=	1.14294679E 02 DEG
X=	-1.89602658E 05 KM	DX=	-7.95296900E-01 KM/S
Y=	2.18362494E 05 KM	DY=	6.11244702E-01 KM/S
Z=	1.13304875E 05 KM	DZ=	2.88275874E-01 KM/S
XM=	-1.37764659E 04 KM	DXM=	8.49788877E-02 KM/S
YM=	-1.03443773E 05 KM	DYM=	9.54671396E-01 KM/S
ZM=	-5.43929574E 04 KM	DZM=	5.02979538E-01 KM/S

G.M.T.=22:00:00.000 APRIL 13

R=	3.14244365E 05 KM	VEL=	1.02988172E 00 KM/S
DECL=	2.13360710E 01 DEG	EL=	7.79065671E 01 DEG
LONG=	-4.05620984E 01 DEG	AZ=	1.14370626E 02 DEG
X=	-1.92449136E 05 KM	DX=	-7.86107778E-01 KM/S
Y=	2.20546137E 05 KM	DY=	6.01946730E-01 KM/S
Z=	1.14333951E 05 KM	DZ=	2.83462601E-01 KM/S
XM=	-1.34610357E 04 KM	DXM=	9.02207826E-02 KM/S
YM=	-1.00010891E 05 KM	DYM=	9.52535837E-01 KM/S
ZM=	-5.25842279E 04 KM	DZM=	5.01897011E-01 KM/S

G.M.T.=23:00:00.000 APRIL 13

R=	3.17846177E 05 KM	VEL=	1.01647993E 00 KM/S
DECL=	2.12783331E 01 DEG	EL=	7.79391515E 01 DEG
LONG=	-5.54666001E 01 DEG	AZ=	1.14447482E 02 DEG
X=	-1.95262831E 05 KM	DX=	-7.77082509E-01 KM/S
Y=	2.22696911E 05 KM	DY=	5.92983228E-01 KM/S
Z=	1.15346021E 05 KM	DZ=	2.78828111E-01 KM/S
XM=	-1.31271529E 04 KM	DXM=	9.52318683E-02 KM/S
YM=	-9.65851504E 04 KM	DYM=	9.50703343E-01 KM/S
ZM=	-5.07791076E 04 KM	DZM=	5.00973994E-01 KM/S

G.M.T.=00:00:00.000 APRIL 14

R=	3.21401911E 05 KM	VEL=	1.00344186E 00 KM/S
DECL=	2.12219710E 01 DEG	EL=	7.79758853E 01 DEG
LONG=	-7.03748848E 01 DEG	AZ=	1.14525628E 02 DEG
X=	-1.98044317E 05 KM	DX=	-7.68212366E-01 KM/S
Y=	2.24816014E 05 KM	DY=	5.84351054E-01 KM/S
Z=	1.16341725E 05 KM	DZ=	2.74370512E-01 KM/S
XM=	-1.27756321E 04 KM	DXM=	1.00021198E-01 KM/S
YM=	-9.31654669E 04 KM	DYM=	9.49170352E-01 KM/S
ZM=	-4.89770263E 04 KM	DZM=	5.00208375E-01 KM/S

G.M.T.=01:00:00.000 APRIL 14

R=	3.24912880E 05 KM	VEL=	9.90759409E-01 KM/S
DECL=	2.11669452E 01 DEG	EL=	7.80175532E 01 DEG
LONG=	-8.52868388E 01 DEG	AZ=	1.14605496E 02 DEG
X=	-2.00794136E 05 KM	DX=	-7.59488896E-01 KM/S
Y=	2.26904635E 05 KM	DY=	5.76049234E-01 KM/S
Z=	1.17321700E 05 KM	DZ=	2.70089064E-01 KM/S
XM=	-1.24072552E 04 KM	DXM=	1.04597562E-01 KM/S
YM=	-8.97507665E 04 KM	DYM=	9.47935473E-01 KM/S
ZM=	-4.71774198E 04 KM	DZM=	4.99599204E-01 KM/S

G.M.T.=02:00:00.000 APRIL 14

R=	3.28380379E 05 KM	VEL=	9.78426372E-01 KM/S
DECL=	2.11132210E 01 DEG	EL=	7.80650526E 01 DEG
LONG=	-1.00202362E 02 DEG	AZ=	1.14687586E 02 DEG
X=	-2.03512803E 05 KM	DX=	-7.50903848E-01 KM/S
Y=	2.28963966E 05 KM	DY=	5.68079161E-01 KM/S
Z=	1.18286579E 05 KM	DZ=	2.65984290E-01 KM/S
XM=	-1.20227742E 04 KM	DXM=	1.08969531E-01 KM/S
YM=	-8.53399741E 04 KM	DYM=	9.46999675E-01 KM/S
ZM=	-4.53797244E 04 KM	DZM=	4.99146784E-01 KM/S

G.M.T.=03:00:00.000 APRIL 14

R= 3.31805694E 05 KM	VEL= 9.66438604E-01 KM/S
DECL= 2.10607684E 01 DEG	EL= 7.81194171E 01 DEG
LONG=-1.15121370E 02 DEG	AZ= 1.14772482E 02 DEG
X=-2.06200800E 05 KM	DX=-7.42449096E-01 KM/S
Y= 2.30995208E 05 KM	DY= 5.60444877E-01 KM/S
Z= 1.19237001E 05 KM	DZ= 2.62058114E-01 KM/S
XM=-1.16229093E 04 KM	DXM= 1.13145562E-01 KM/S
YM=-8.29320072E 04 KM	DYM= 9.46366585E-01 KM/S
ZM=-4.35833732E 04 KM	DZM= 4.98852827E-01 KM/S

G.M.T.=04:00:00.000 APRIL 14

R= 3.35190110E 05 KM	VEL= 9.54794222E-01 KM/S
DECL= 2.10095621E 01 DEG	EL= 7.81818466E 01 DEG
LONG=-1.30043793E 02 DEG	AZ= 1.14860878E 02 DEG
X=-2.08858583E 05 KM	DX=-7.34116553E-01 KM/S
Y= 2.32999581E 05 KM	DY= 5.53153450E-01 KM/S
Z= 1.20173615E 05 KM	DZ= 2.58314060E-01 KM/S
XM=-1.12083509E 04 KM	DXM= 1.17134071E-01 KM/S
YM=-7.95257649E 04 KM	DYM= 9.46042856E-01 KM/S
ZM=-4.17877903E 04 KM	DZM= 4.98720644E-01 KM/S

G.M.T.=05:00:00.000 APRIL 14

R= 3.38534925E 05 KM	VEL= 9.43493907E-01 KM/S
DECL= 2.09595821E 01 DEG	EL= 7.82537452E 01 DEG
LONG=-1.44969573E 02 DEG	AZ= 1.14953607E 02 DEG
X=-2.11486576E 05 KM	DX=-7.25898076E-01 KM/S
Y= 2.34978337E 05 KM	DY= 5.46215477E-01 KM/S
Z= 1.21097087E 05 KM	DZ= 2.54757509E-01 KM/S
XM=-1.07797587E 04 KM	DXM= 1.20943535E-01 KM/S
YM=-7.61201164E 04 KM	DYM= 9.46038671E-01 KM/S
ZM=-3.99923845E 04 KM	DZM= 4.98755405E-01 KM/S

G.M.T.=06:00:00.000 APRIL 14

R= 3.41841453E 05 KM	VEL= 9.32541321E-01 KM/S
DECL= 2.09108132E 01 DEG	EL= 7.83367688E 01 DEG
LONG=-1.59898673E 02 DEG	AZ= 1.15051688E 02 DEG
X=-2.14085176E 05 KM	DX=-7.17785350E-01 KM/S
Y= 2.36932774E 05 KM	DY= 5.39645747E-01 KM/S
Z= 1.22008103E 05 KM	DZ= 2.51396049E-01 KM/S
XM=-1.03377618E 04 KM	DXM= 1.24582603E-01 KM/S
YM=-7.27138869E 04 KM	DYM= 9.46368407E-01 KM/S
ZM=-3.81965422E 04 KM	DZM= 4.98964486E-01 KM/S

G.M.T.=07:00:00.000 APRIL 14

R=	3.45111048E 05 KM	VEL=	9.21943675E-01 KM/S
DECL=	2.08632461E 01 DEG	EL=	7.84328881E 01 DEG
LONG=	-1.74831068E 02 DEG	AZ=	1.15156380E 02 DEG
X=	-2.16654747E 05 KM	DX=	-7.09769749E-01 KM/S
Y=	2.38864252E 05 KM	DY=	5.33464130E-01 KM/S
Z=	1.22907385E 05 KM	DZ=	2.48239934E-01 KM/S
XM=	-9.88295766E 03 KM	DXM=	1.28060237E-01 KM/S
YM=	-6.93058408E 04 KM	DYM=	9.47051525E-01 KM/S
ZM=	-3.53996169E 04 KM	DZM=	4.99357932E-01 KM/S

G.M.T.=08:00:00.000 APRIL 14

R=	3.48345111E 05 KM	VEL=	9.11712519E-01 KM/S
DECL=	2.08168776E 01 DEG	EL=	7.85444692E 01 DEG
LONG=	1.70233244E 02 DEG	AZ=	1.15269269E 02 DEG
X=	-2.19195624E 05 KM	DX=	-7.01842162E-01 KM/S
Y=	2.40774212E 05 KM	DY=	5.27696769E-01 KM/S
Z=	1.23795693E 05 KM	DZ=	2.45302703E-01 KM/S
XM=	-9.41591061E 03 KM	DXM=	1.31385885E-01 KM/S
YM=	-6.58946618E 04 KM	DYM=	9.48113760E-01 KM/S
ZM=	-3.46009278E 04 KM	DZM=	4.99949073E-01 KM/S

G.M.T.=09:00:00.000 APRIL 14

R=	3.51545117E 05 KM	VEL=	9.01864827E-01 KM/S
DECL=	2.07717115E 01 DEG	EL=	7.86743813E 01 DEG
LONG=	1.55294248E 02 DEG	AZ=	1.15392383E 02 DEG
X=	-2.21708105E 05 KM	DX=	-6.93992772E-01 KM/S
Y=	2.42664206E 05 KM	DY=	5.22377695E-01 KM/S
Z=	1.24673848E 05 KM	DZ=	2.42602023E-01 KM/S
XM=	-8.93714956E 03 KM	DXM=	1.34569702E-01 KM/S
YM=	-6.24789270E 04 KM	DYM=	9.49588737E-01 KM/S
ZM=	-3.27997271E 04 KM	DZM=	5.00755370E-01 KM/S

G.M.T.=10:00:00.000 APRIL 14

R=	3.54712634E 05 KM	VEL=	8.92424522E-01 KM/S
DECL=	2.07277594E 01 DEG	EL=	7.88261411E 01 DEG
LONG=	1.40351903E 02 DEG	AZ=	1.15528366E 02 DEG
X=	-2.24192453E 05 KM	DX=	-6.86210765E-01 KM/S
Y=	2.44535922E 05 KM	DY=	5.17551044E-01 KM/S
Z=	1.25542739E 05 KM	DZ=	2.40160842E-01 KM/S
XM=	-8.44716577E 03 KM	DXM=	1.37622842E-01 KM/S
YM=	-5.90570755E 04 KM	DYM=	9.51520186E-01 KM/S
ZM=	-3.09952033E 04 KM	DZM=	5.01799561E-01 KM/S

G.M.T.=11:00:00.000 APRIL 14

R=	3.57849362E 05 KM	VEL=	8.83424640E-01 KM/S
DECL=	2.06850422E 01 DEG	EL=	7.90041095E 01 DEG
LONG=	1.25406139E 02 DEG	AZ=	1.15680740E 02 DEG
X=	-2.26648889E 05 KM	DX=	-6.78483943E-01 KM/S
Y=	2.46391233E 05 KM	DY=	5.13274149E-01 KM/S
Z=	1.26403353E 05 KM	DZ=	2.38008995E-01 KM/S
XM=	-7.94640735E 03 KM	DXM=	1.40557844E-01 KM/S
YM=	-5.56273600E 04 KM	DYM=	9.53965038E-01 KM/S
ZM=	-2.91864490E 04 KM	DZM=	5.03111277E-01 KM/S

G.M.T.=12:00:00.000 APRIL 14

R=	3.50957173E 05 KM	VEL=	8.74910460E-01 KM/S
DECL=	2.06435924E 01 DEG	EL=	7.92137661E 01 DEG
LONG=	1.10456854E 02 DEG	AZ=	1.15854306E 02 DEG
X=	-2.29077586E 05 KM	DX=	-6.70798188E-01 KM/S
Y=	2.48232245E 05 KM	DY=	5.09621937E-01 KM/S
Z=	1.27256797E 05 KM	DZ=	2.36185492E-01 KM/S
XM=	-7.43527429E 03 KM	DXM=	1.43389168E-01 KM/S
YM=	-5.21878222E 04 KM	DYM=	9.56997818E-01 KM/S
ZM=	-2.73724344E 04 KM	DZM=	5.04729322E-01 KM/S

G.M.T.=13:00:00.000 APRIL 14

R=	3.54038168E 05 KM	VEL=	8.66944136E-01 KM/S
DECL=	2.06034561E 01 DEG	EL=	7.94620965E 01 DEG
LONG=	9.55039018E 01 DEG	AZ=	1.16055791E 02 DEG
X=	-2.31478665E 05 KM	DX=	-6.63136713E-01 KM/S
Y=	2.50061377E 05 KM	DY=	5.06693309E-01 KM/S
Z=	1.28104343E 05 KM	DZ=	2.34741828E-01 KM/S
XM=	-6.91410952E 03 KM	DXM=	1.46133953E-01 KM/S
YM=	-4.87361595E 04 KM	DYM=	9.60717033E-01 KM/S
ZM=	-2.55519694E 04 KM	DZM=	5.06704992E-01 KM/S

G.M.T.=14:00:00.000 APRIL 14

R=	3.57094759E 05 KM	VEL=	8.59611724E-01 KM/S
DECL=	2.05646969E 01 DEG	EL=	7.97581556E 01 DEG
LONG=	8.05470838E 01 DEG	AZ=	1.16294934E 02 DEG
X=	-2.33852176E 05 KM	DX=	-6.55478980E-01 KM/S
Y=	2.51881462E 05 KM	DY=	5.04620649E-01 KM/S
Z=	1.28947476E 05 KM	DZ=	2.33746922E-01 KM/S
XM=	-6.38318873E 03 KM	DXM=	1.48813074E-01 KM/S
YM=	-4.52696801E 04 KM	DYM=	9.65254661E-01 KM/S
ZM=	-2.37236483E 04 KM	DZM=	5.09106998E-01 KM/S

G.M.T.=15:00:00.000 APRIL 14

R=	3.70129784E 05 KM	VEL=	8.53034190E-01 KM/S
DECL=	2.05274015E 01 DEG	EL=	8.01139051E 01 DEG
LONG=	6.55861312E 01 DEG	AZ=	1.16586390E 02 DEG
X=	-2.36198087E 05 KM	DX=	-6.47799095E-01 KM/S
Y=	2.53695887E 05 KM	DY=	5.03584407E-01 KM/S
Z=	1.29787971E 05 KM	DZ=	2.33294676E-01 KM/S
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YM=	-4.17851311E 04 KM	DYM=	9.70790756E-01 KM/S
ZM=	-2.18857769E 04 KM	DZM=	5.12029039E-01 KM/S

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DECL=	2.04916869E 01 DEG	EL=	8.05454952E 01 DEG
LONG=	5.06206817E 01 DEG	AZ=	1.16953293E 02 DEG
X=	-2.38516262E 05 KM	DX=	-6.40063351E-01 KM/S
Y=	2.55508811E 05 KM	DY=	5.03836276E-01 KM/S
Z=	1.30628004E 05 KM	DZ=	2.33515977E-01 KM/S
XM=	-5.29273584E 03 KM	DXM=	1.54087106E-01 KM/S
YM=	-3.92784916E 04 KM	DYM=	9.77576613E-01 KM/S
ZM=	-2.00362611E 04 KM	DZM=	5.15601800E-01 KM/S

G.M.T.=17:00:00.000 APRIL 14

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DECL=	2.04577120E 01 DEG	EL=	8.10752968E 01 DEG
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X=	-2.40806423E 05 KM	DX=	-6.32226331E-01 KM/S
Y=	2.57325481E 05 KM	DY=	5.05737577E-01 KM/S
Z=	1.31470316E 05 KM	DZ=	2.34598545E-01 KM/S
XM=	-4.73322823E 03 KM	DXM=	1.56761836E-01 KM/S
YM=	-3.47446535E 04 KM	DYM=	9.85973162E-01 KM/S
ZM=	-1.81724419E 04 KM	DZM=	5.20012802E-01 KM/S

G.M.T.=18:00:00.000 APRIL 14

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DECL=	2.04256963E 01 DEG	EL=	8.17352436E 01 DEG
LONG=	2.06741373E 01 DEG	AZ=	1.18100215E 02 DEG
X=	-2.43068095E 05 KM	DX=	-6.24224478E-01 KM/S
Y=	2.59152735E 05 KM	DY=	5.09826142E-01 KM/S
Z=	1.32318476E 05 KM	DZ=	2.36821468E-01 KM/S
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YM=	-3.11769184E 04 KM	DYM=	9.96517837E-01 KM/S
ZM=	-1.62908345E 04 KM	DZM=	5.25540931E-01 KM/S

G.M.T.=19:00:00.000 APRIL 14

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DECL=	2.03959496E 01 DEG	EL=	8.25725685E 01 DEG
LONG=	5.69140425E 00 DEG	AZ=	1.19093029E 02 DEG
X=	-2.45300531E 05 KM	DX=	-6.15964926E-01 KM/S
Y=	2.60999839E 05 KM	DY=	5.16940311E-01 KM/S
Z=	1.33177310E 05 KM	DZ=	2.40619094E-01 KM/S
XM=	-3.58429939E 03 KM	DXM=	1.62517438E-01 KM/S
YM=	-2.75661622E 04 KM	DYM=	1.01004859E 00 KM/S
ZM=	-1.43866965E 04 KM	DZM=	5.32620336E-01 KM/S

G.M.T.=20:00:00.000 APRIL 14

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X=	-2.47502566E 05 KM	DX=	-6.07304988E-01 KM/S
Y=	2.62879960E 05 KM	DY=	5.28467805E-01 KM/S
Z=	1.34053663E 05 KM	DZ=	2.46708957E-01 KM/S
XM=	-2.99339690E 03 KM	DXM=	1.65834569E-01 KM/S
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LONG=	-2.43003289E 01 DEG	AZ=	1.24109949E 02 DEG
X=	-2.49672374E 05 KM	DX=	-5.98011780E-01 KM/S
Y=	2.64813003E 05 KM	DY=	5.46900070E-01 KM/S
Z=	1.34957860E 05 KM	DZ=	2.56375859E-01 KM/S
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ZM=	-1.04803069E 04 KM	DZM=	5.54869584E-01 KM/S

G.M.T.=22:00:00.000 APRIL 14

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DECL=	2.03262721E 01 DEG	EL=	8.71076414E 01 DEG
LONG=	-3.93151078E 01 DEG	AZ=	1.34515564E 02 DEG
X=	-2.51807014E 05 KM	DX=	-5.87676465E-01 KM/S
Y=	2.66831716E 05 KM	DY=	5.77259407E-01 KM/S
Z=	1.35906837E 05 KM	DZ=	2.72200236E-01 KM/S
XM=	-1.77020853E 03 KM	DXM=	1.74599449E-01 KM/S
YM=	-1.63057399E 04 KM	DYM=	1.08937637E 00 KM/S
ZM=	-8.45096672E 03 KM	DZM=	5.73904270E-01 KM/S

G.M.T.=23:00:00.000 APRIL 14

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DECL=	2.03139223E 01 DEG	EL=	8.86591868E 01 DEG
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Y=	2.58997312E 05 KM	DY=	6.31667933E-01 KM/S
Z=	1.36932110E 05 KM	DZ=	3.00376415E-01 KM/S
XM=	-1.13041233E 03 KM	DXM=	1.81232783E-01 KM/S
YM=	-1.22852516E 04 KM	DYM=	1.15003948E 00 KM/S
ZM=	-6.33381660E 03 KM	DZM=	6.05266543E-01 KM/S

G.M.T.=00:00:00.000 APRIL 15

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X=	-2.55946912E 05 KM	DX=	-5.60162483E-01 KM/S
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G.M.T.=01:00:00.000 APRIL 15

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X=	-2.57941087E 05 KM	DX=	-5.62646287E-01 KM/S
Y=	2.74790086E 05 KM	DY=	1.29371022E 00 KM/S
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YM=	-2.71551784E 03 KM	DYM=	1.82446615E 00 KM/S
ZM=	-1.32043828E 03 KM	DZM=	9.43032785E-01 KM/S

LUNAR IMPACT

G.M.T.=01:09:39.124 APRIL 15

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X=	-2.58280726E 05 KM	DX=	-6.32873177E-01 KM/S
Y=	2.75651087E 05 KM	DY=	1.76574540E 00 KM/S
Z=	1.40147121E 05 KM	DZ=	8.56527579E-01 KM/S
XM=	3.30256199E 02 KM	DXM=	1.11755462E-01 KM/S
YM=	-1.54685733E 03 KM	DYM=	2.29749016E 00 KM/S
ZM=	-7.20499836E 02 KM	DZM=	1.16821881E 00 KM/S
LATM=	-2.34171932E 00 DEG	LONGM=	-2.79693421E 01 DEG
B.R=	-1.23518853E 02 KM	B.T=	1.03813991E 03 KM

APPENDIX

Coordinate System Definition and Identification of Trajectory Parameters

I. Standard Apollo Coordinate System 1 (Geographic Polar)

Geographic Polar is a rotating, earth-referenced coordinate system with its origin at the center of the earth.

R = magnitude of the geocentric radius vector to the center of gravity of the vehicle (km)

DECL = geocentric declination; angle between the geocentric radius vector and the true equatorial plane measured positive north and negative south of the true equatorial plane (degrees).

LONG = longitude measured positive eastward from the prime (Greenwich) meridian to the meridian containing the vehicle, degrees.

VS = magnitude of the inertial velocity vector of the vehicle (km/sec).

EL = flight path angle measured positive upward to the velocity vector from the plane normal to the geocentric radius vector (degrees).

AZ = azimuth angle from north of the velocity vector projected on a plane normal to the geocentric radius vector to the vehicle (degrees).

II. Standard Apollo Coordinate System 4 (Geocentric Inertial)

Geocentric Inertial is a nonrotating, earth-referenced coordinate system with its origin at the center of the earth. The reference epoch is the mean nearest Besselian year.

X = component of R along an axis directed toward the mean vernal equinox (km).

Z = component of R directed along the earth's mean rotational axis, positive north (km).

Y = component of R in the direction which completes a standard right-handed system (km).

DX,DZ,DY = components of VS along the respective directions defined above (km/sec).

III. Standard Apollo Coordinate System 4 (Selenocentric Inertial)

Selenocentric Inertial is a nonrotating, moon-referenced coordinate system with its origin at the center of the moon. The reference epoch is the mean nearest Besselian year.

XM = component of the radius vector (RM) from the selenocenter to the vehicle along an axis directed toward the mean vernal equinox (km).

ZM = component of RM directed along an axis parallel to the earth's spin axis (km).

YM = component of RM in the direction which completes a standard right-handed system (km).

DXM,DZM, DYM = components of the moon referenced inertial velocity vector along the respective directions defined above (km/sec).

IV. Standard Apollo Coordinate System 2 (Selenographic Polar)

Selenographic Polar is a rotating, moon-referenced coordinate system with its origin at the center of the moon.

LATM = angle defined by the intersection of the selenocentric radius vector to the vehicle and the true lunar equatorial plane, positive north toward Mare Serenitatas and negative south of the true lunar equator (degrees).

Z = component of R directed along the earth's mean rotational axis, positive north (km).

Y = component of R in the direction which completes a standard right-handed system (km).

DX,DZ,DY = components of VS along the respective directions defined above (km/sec).

LONGM = angle measured along the equatorial arc from the prime meridian to the meridian containing the vehicle, positive eastward toward Mare Crisium (degrees).

RM = $\sqrt{XM^2 + YM^2 + ZM^2}$; radial distance from the selenocenter to the vehicle (km).

V. Lunar Targeting Coordinate System (S-T-R System) and Miss Parameter B

STR system has its origin at the center of the moon and is redefined at the beginning of each computational cycle - the orientation of the axes depending on the position and orientation of the incoming asymptote.

S = unit vector in the direction of the incoming asymptote of the vehicle trajectory.

T = unit vector perpendicular to the incoming asymptote and lying in the lunar flight plane, positive in a direction retrograde to the moon's orbital velocity vector.

R = S X T

B = a vector from the origin of the S-T-R system intersecting and perpendicular to the incoming asymptote.

B·R, B·T = lunar targeting coordinates (km).

REFERENCES

1. Apollo Program Office document, "Mission Implementation Plan for the Apollo 13 (H-2) Mission," NASA Headquarters, December 9, 1969.

2. TBC memorandum 5-9400-H-423, "Saturn AS-508 H-2 Mission Launch Vehicle Operational Flight Trajectory - April Launch Month," The Boeing Company, Huntsville, Alabama, January 5, 1970.

3. Flight Evaluation Working Group, "Saturn V Launch Vehicle Flight Evaluation Report AS-508 Apollo 13 Mission," MSFC document MPR-SAT-FE-70-2, Marshall Space Flight Center, Alabama, June 20, 1970.

APPROVAL

AS-508 S-IVB POSTFLIGHT LUNAR IMPACT TRAJECTORY ANALYSIS

by W. D. McFadden and I. M. Salzberg

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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